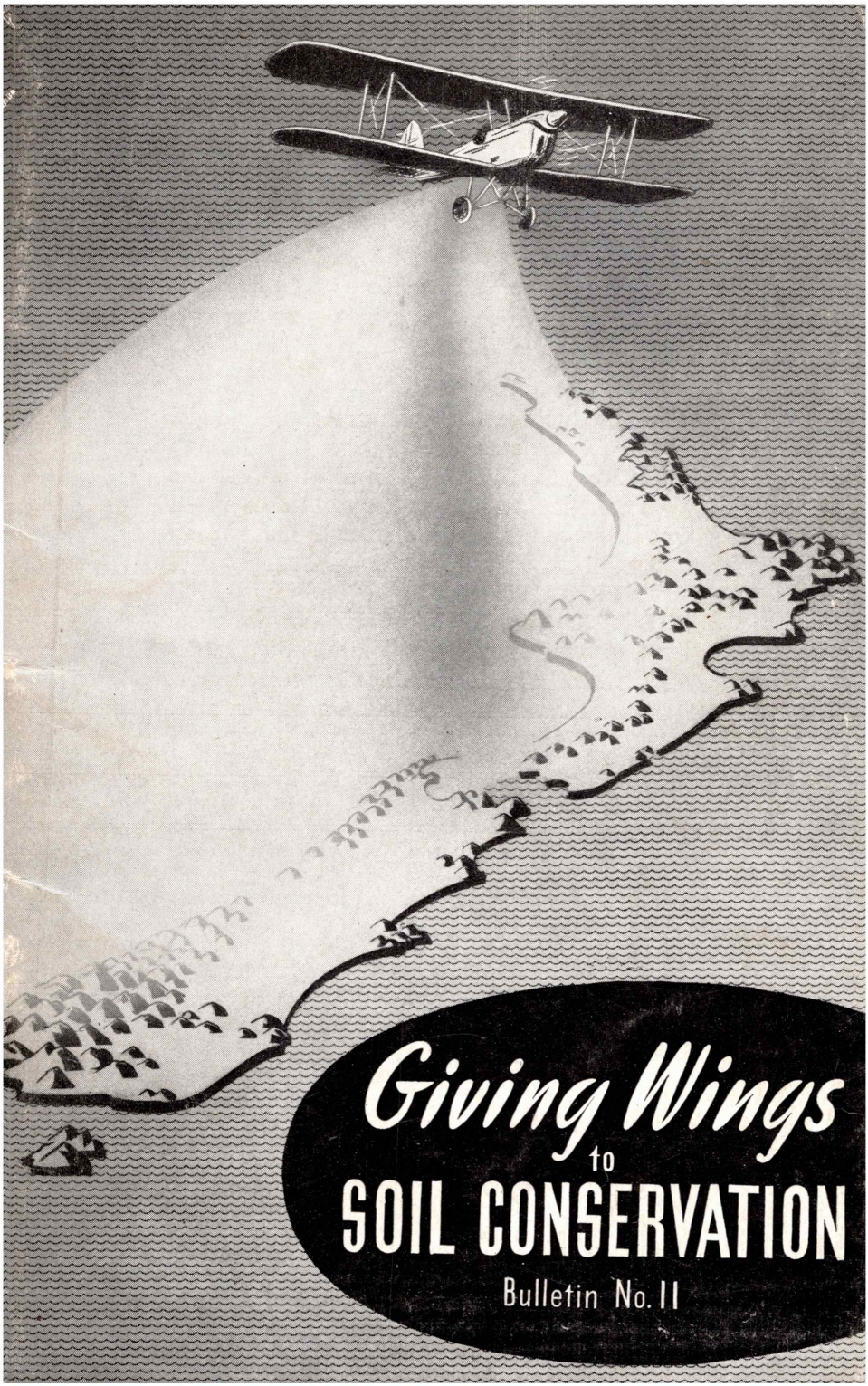
Giving Wings
to
SOIL CONSERVATION
Bulletin No. 11

Giving Wings to Soil Conservation

Tiger Moth aircraft have done most of the aerial topdressing to date.

In five years 750,000 tons of phosphate has been distributed by aircraft on hill country – a task that is roughly equivalent to $1\frac{1}{2}$ million man and packhorse days.

This is sufficient fertilizer to topdress upwards of 7 million acres of hill country at the usual rates, or 3 million acres at the rate of 5 cwt. per acre, which would raise its carrying capacity from one sheep to more than two sheep per acre.

GIVING WINGS TO SOIL CONSERVATION

by

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Contents

Foreword

IN REVIEWING the progress in soil conservation over the first 10 years of our operations it is gratifying to record that the organized investigations, trials and demonstrations undertaken to find solutions for the country's erosion problems have yielded results of far reaching importance.

Conservation practices have been evolved which when used singly, or in combination with each other, will very much improve the capacity of the soil to regulate the movement of water and resist soil erosion. By showing that these practices can be made more effective if combined with good farming practices with resulting permanent protection of the soil and continued production, valuable contributions have been made to our great agricultural industry.

The next phase in our operation is the active adoption of these conservation practices on farms, and the Council urges all farmers to make full use of the facilities provided by Council and Catchment Boards and solicits their active support so that this second and practical phase of the work can be as successful as the first or experimental phase.

Chairman,
Soil Conservation and Rivers Control Council,
1955

Introduction

THE TREMENDOUSLY rapid development of aerial topdressing on problem hill country is proving to be a spectacular step in soil conservation. To be effective as a conservation tool it must be backed up by other conservation practices, such as oversowing with clover grasses; subdivision fencing to make spelling and grazing control effective; greater use of cattle; tree planting to stabilize steep slopes and gullies; contouring to promote soil and water control; fire and pest control and storage of water in flood control dams.

Used in various combinations to support one another these conservation and farming practices form the basis of a new hill-country farming system which can be adapted to meet the requirements of our dominantly hilly and high country to assure permanent production at new and higher levels and at the same time minimize soil erosion and flooding. Such a hill-country farming system, significantly enough, forms the basis of catchment control when linked with the appropriate river control works.

These integrated conservation measures made possible by the rapid expansion of aerial topdressing, seeding, rabbit poisoning, weed spraying, fire patrol, fence and supply dropping, when supported by improved management, actually give wings to Soil Conservation.

CHAPTER I

Devising Soil Conservation Practices

THE CHALLENGE OF soil erosion and flooding, which were jeopardizing the country's vital soil and water resources, had in 1941 become so acute that legislation was enacted in an endeavour to prevent soil erosion and damage by floods, to promote soil and water conservation, and to utilize the land in such a way that these objectives would be ultimately achieved. The first step was the setting up of the Soil Conservation and Rivers Control Council and the initiation of complete investigations into the problems.

These investigations in problem catchments soon revealed that farming had drastically changed the vegetation and, in consequence, the soil and its fertility. The general result was that the land had developed a downward trend as evidenced by soil exhaustion, pasture deterioration, consolidation, loss of soil structure, and increased run-off causing sheet, slip, and gully erosion. The consequent passing down the river system of the effect of accelerated erosion brought about the filling of stream channels with debris, bank erosion, higher peak flows, flooding, and the impairment of drainage and damage to productive alluvial lands.

Soil erosion and flooding exact a double toll by impoverishing the hill country and damaging the lowlands.

The cumulative effects of burning, grazing, cultivation, and pests caused this downward trend by consolidating the soil and exposing it to the normal agents of erosion while denying it the necessary additions of organic matter. This impaired the fertility, the structure, and the root-bonding which characterized the soil under its original vegetation.

Thus the moisture-holding capacity of the soil and its mantle of vegetation, which constitutes the greatest natural stabilizing and absorbing medium for the control of water, was impaired progressively.

Conservation depended primarily on restoring the soil's capacity to grow protective and stabilizing vegetation so that both soil and vegetation might exercise their powers to absorb and retard the movement of water.

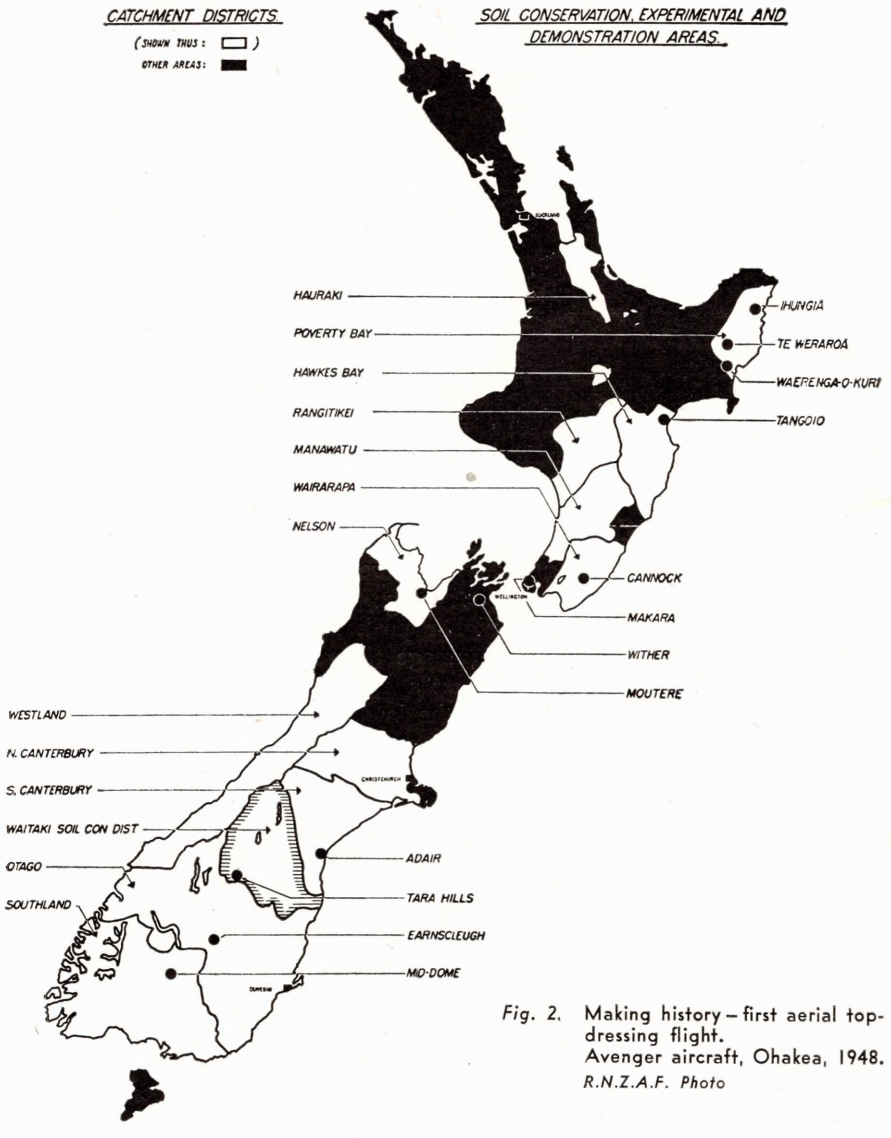


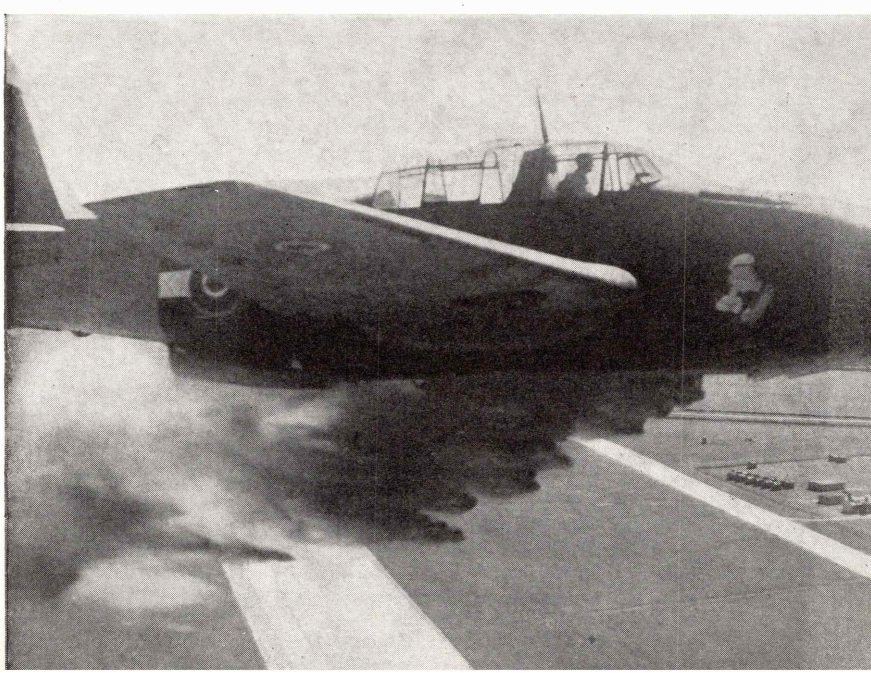
Fig. 2. Making history – first aerial top-dressing flight.
Avenger aircraft, Ohakea, 1948.
R.N.Z.A.F. Photo

As this is largely a matter of managing the land, the problem became one of evolving acceptable land-use practices which would fit in with the grassland-farming and forestry-management requirements of the hill country affected. Since 70 per cent of the area of New Zealand is hilly and high country, and as much of it suffers from soil erosion and increased run-off, our conservation problems are largely problems of hill-country management.

The first step in promoting soil conservation on most of this hill country was to rebuild the fertility and structure of the soil and enhance its capacity to grow protective vegetation, both of which could be achieved by topdressing and oversowing, coupled with suitable management. On the drier hill country, fire and pest control were being undertaken simultaneously.

Experience on experimental and demonstration farms had confirmed the fact that suitable soil-conservation and prudent-farming practices could be combined and adapted to meet the requirements of conservation and at the same time bring about permanent production at new and higher levels.

But the fact remained that fertilizer was the "starter" required and that before it could be applied to steep, rugged country such formidable obstacles as lack of access, shortage and high cost of labour, lack of fencing to control stock, clover-deficient pastures, and traditional acceptance by farmers that depletion, erosion, and scrub invasion were the inescapable fate of hill country, had to be surmounted.



It was under these circumstances that the Council initiated the original aerial topdressing trials and demonstrations as a practical method of distributing fertilizer if soil conservation was to be made a practical possibility on hill country. Further, the primary requirements of soil conservation could be attained by developing combined practices that would combat erosion and be sufficiently practical and attractive for farmers to adopt them of their own volition.

Although aerial topdressing has caught the imagination of both private operators and farmers alike, it must be kept in perspective as the first step in making possible a new conservation farming system devised to meet the needs of our problem hill country.

The full benefit and national objective of aerial topdressing can only accrue when it is effectively integrated with, and supported by, sound conservation farming practices such as oversowing, spelling, rotational grazing, greater use of cattle, tree planting to stabilize steep land, subdivisional fencing, gully control, stock water ponds, flood-control dams, and, where possible, contouring. Conversely, aerial topdressing endows this unified conservation farming system for hill country with chain-reaction characteristics, as a fertility-building spiral is developed that assures increased protection, production, and control of water.

Thus the promotion of soil conservation depends upon developing a successful practical conservation-farming system for the problematic hill country, the components of which are examined in succeeding chapters.

CHAPTER II

Promoting Aerial Topdressing and Other Services

SINCE GRASS HAS BEEN forced to take over a large proportion of the protective functions of shrub, forest, and swamp vegetation, and as it is the economic basis of land use, its improvement must be the key to any worth-while soil-conservation programme.

To be practicable such a programme would have to be both profitable to the farmer and effective in stabilizing soil and controlling run-off.

As phosphate had proved to be the "yeast" of the primary industry (topdressing and oversowing comprising the established basis of our modern grassland economy on easy-rolling land), it was logical to tackle hill-country conservation by alleviating soil exhaustion and mineral deficiencies first.

The rugged nature of the country, poor access, and the high cost of labour placed such limitations on orthodox methods of topdressing that little or no progress could be made in breaking the back of this stupendous task of improving millions of acres of hilly pastures unless new methods of distributing fertilizers were evolved.

Although the cost of distributing fertilizer from aeroplanes was commonly accepted as prohibitive, the dual conservation benefits – direct increases in production and indirect alleviation of soil erosion and flooding – justified a full investigation by the Council.

FIRST PHASE OF DEVELOPMENT

Accordingly the author submitted proposals, which were strongly supported by the Chairman, Mr W. L. Newnham, and adopted by the Council in July 1947. The Council authorized £600 for practical field trials with a Dakota aircraft, and called a meeting later of those Departments interested to implement its resolution. As a Dakota was not readily convertible and this exploratory work promised to provide an additional use for heavy aircraft, the project won the support of the R.N.Z.A.F. to the extent that it converted a Grumman Avenger aircraft for the purpose.

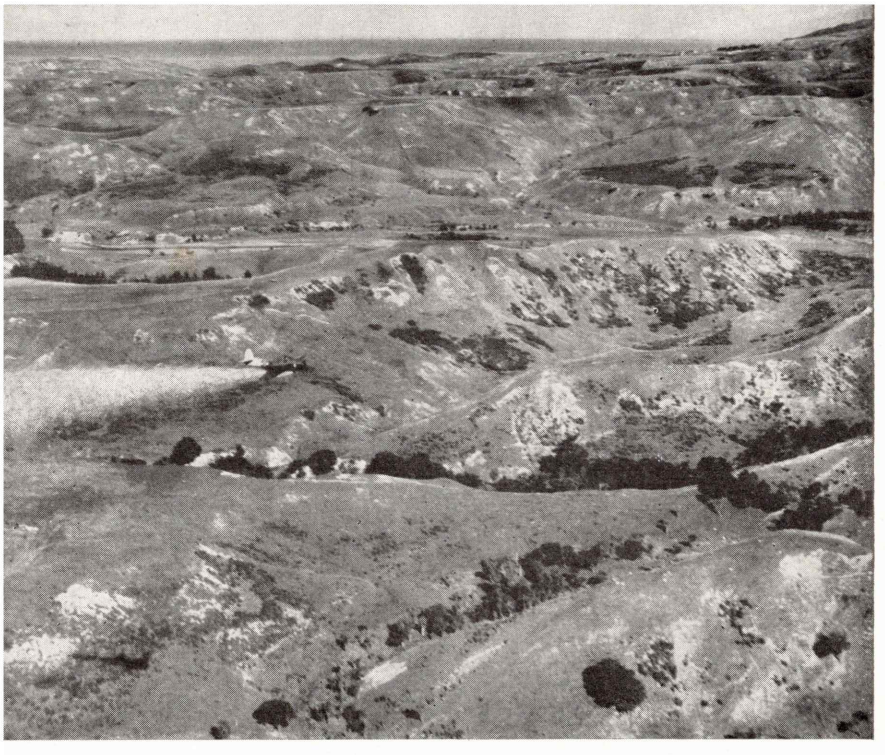


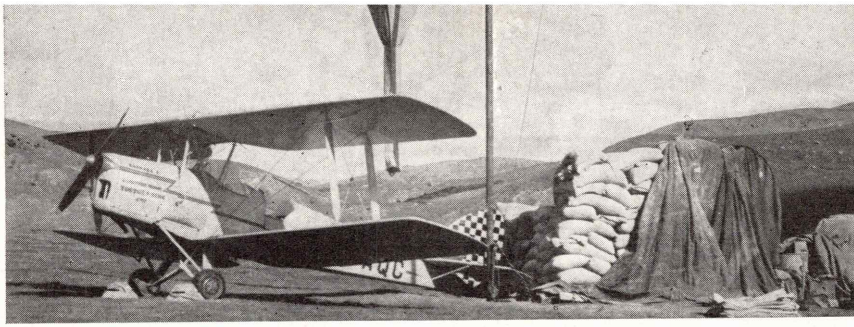
Fig. 3. Demonstrating the new farm implement and conservation tool – Wairarapa hill country, 1949.

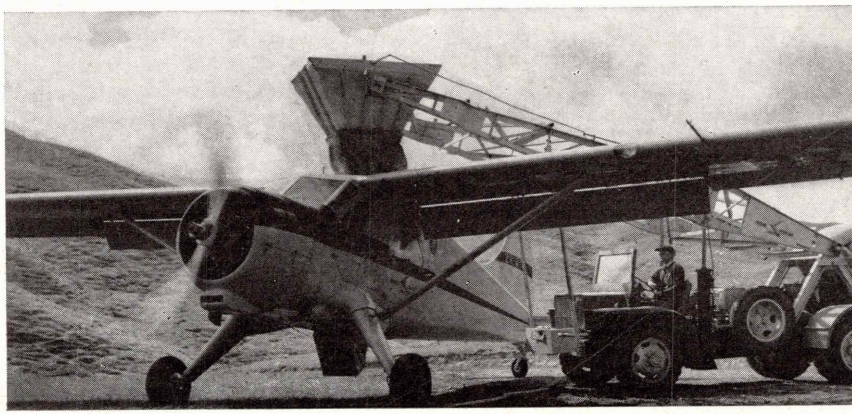
Fig. 4. The Small Machine that has done a Big Job.
Tiger Moths have distributed most of the three-quarter's of a million tons of Phosphate applied to date.

Rapid mechanical loading of a Beaver aircraft – three-quarter's of a ton in ten seconds.

A Beaver bombing hilly pastures with fertility-building phosphate.

Fletcher's Utility Aircraft – specially designed flying topdresser with loader. J. R. Adams photo.





The original trials carried out in September 1948 at Ohakea, and followed up by hill-country trials, established beyond doubt that aerial topdressing was a practicable flying operation and that a satisfactory distribution of granulated fertilizers at desired rates of application could be obtained.

There were no insurmountable difficulties in using this method on hill country, but the very significant fact that a new farming implement was born to usher in the aerial-farming age was not widely appreciated, and consequently it was necessary to make this fact more widely known.

Accordingly a 1,000-acre trial on several widely scattered, typical hill-country farms was organized by the Council and the R.N.Z.A.F. in the Wairarapa. The operation was carried out very creditably by the Air Force, which coped successfully with the varied hill-country terrain at distances up to thirty miles from the aerodrome. Agricultural experts and farmers alike considered that a better distribution could not be obtained on such country by alternative methods.

Up to this stage aerial topdressing had been sponsored and developed by team work among Government Departments, but the tremendous task of equipping and organizing the operation of a fleet of aircraft with the necessary ground installations and staff was beyond the resources of such a team and seemed to be more suitable for private enterprise.

It was very timely that these trials engendered a wave of enthusiasm and initiative among would-be operators and farmers alike and prepared the way for the next phase in the development of aerial topdressing.

SECOND PHASE OF DEVELOPMENT

Within a few months of the large-scale demonstration being completed, four private operators were seized with the possibilities of commercially developing aerial-topdressing services, while progressive farmers shared this enthusiasm by making suitable landing strips. Practical pilots with the experience of a war behind them adapted obsolete but available small Tiger Moth aircraft and developed loading equipment for the purpose.

A low-flying (50 ft.) cross-wind technique was developed that provided a satisfactory spread of powdery phosphate, while three-minute turn-rounds (from take-off to take-off) soon made it possible to put on from 10 tons to 60 tons of super per day with these machines.

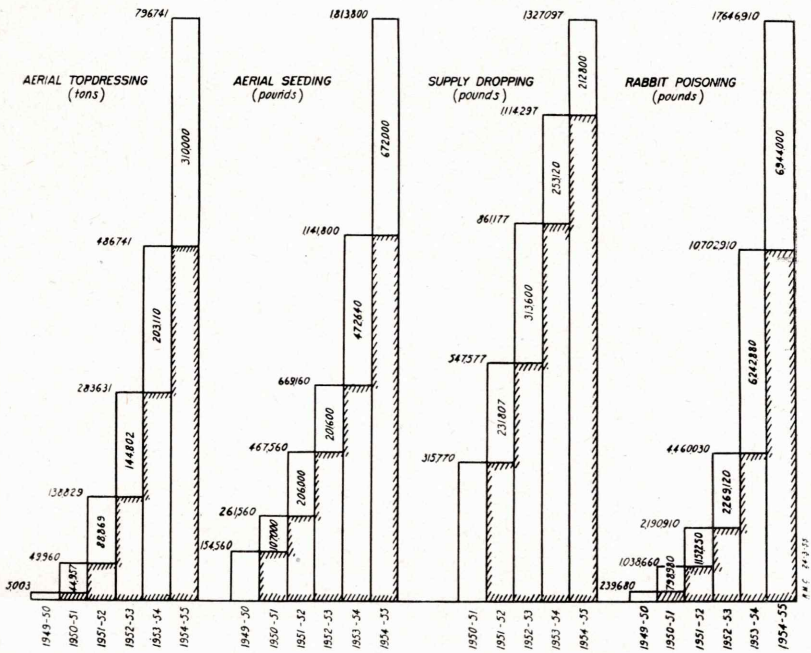
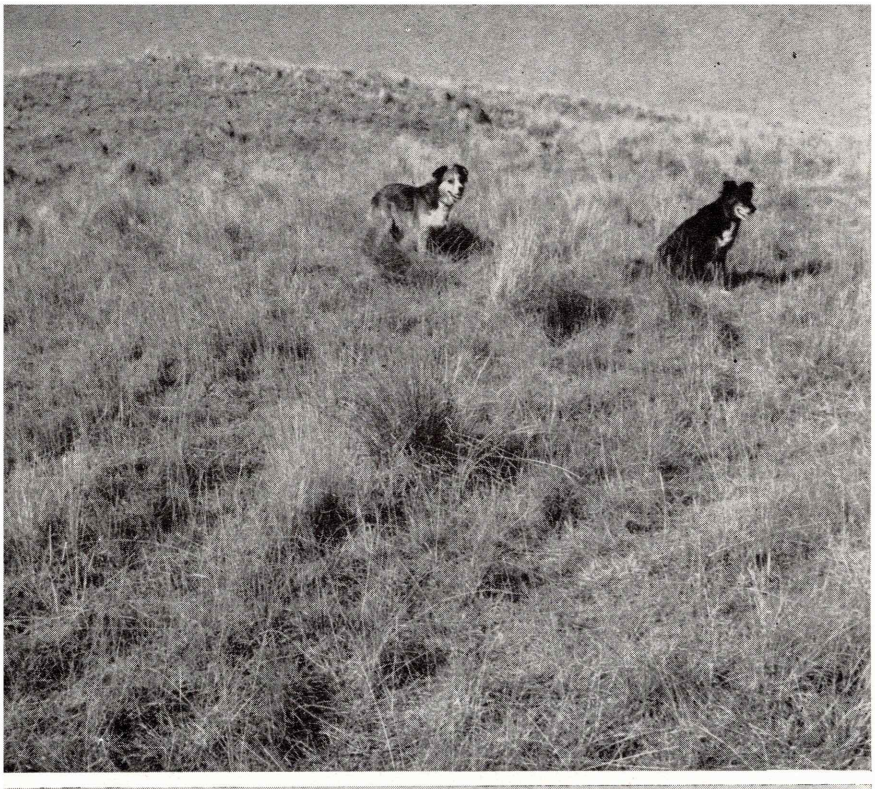
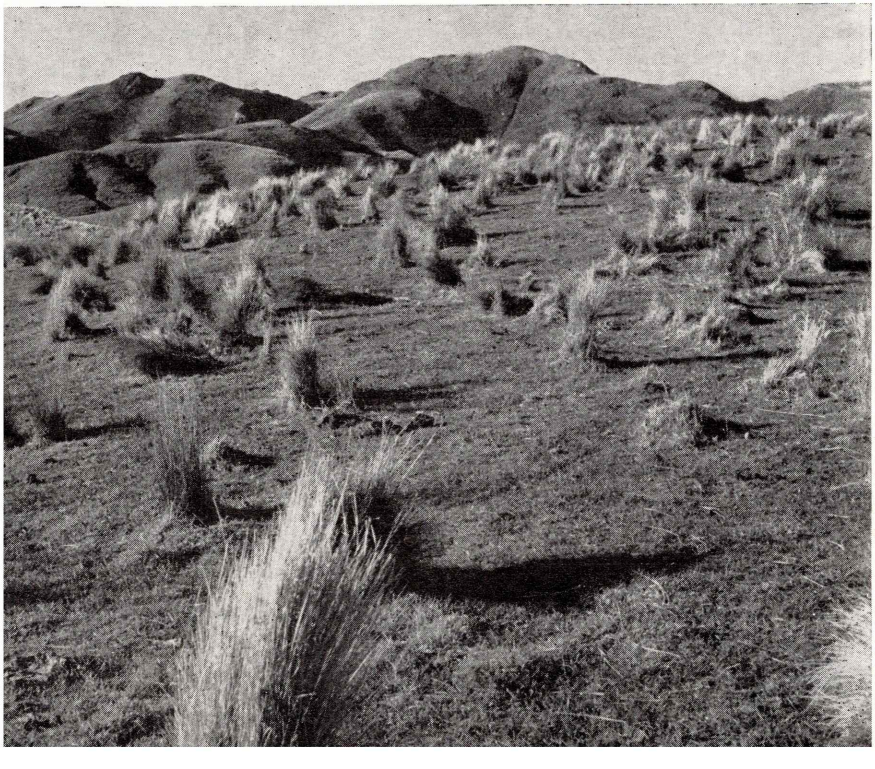


Fig. 5. **Weights of materials distributed by major operations.**

In six years aerial topdressing has mushroomed into big business. Forty-six operators employ over two hundred aircraft worth £500,000 and have equipment, buildings, and spares worth £200,000. Farmers have made thousands of landing strips, the cost of which varies from a few pounds to several hundred. To date 762,000 tons of phosphate, 7,500 tons of rabbit poison, 800 tons each of seeds and supplies (including fencing), and 120 tons of spray materials have been distributed.

The farmers have invested over £10 million in these materials, the annual return from which being estimated to be worth £5 million and the improvement in land upwards of £25 million. The indirect benefit from the control of erosion and floods on the 2 to 3 million acres of hill country that have been treated cannot be estimated, but already a substantial portion of the original target area of 10 million acres of hill country responsive to phosphate and trace elements such as molybdenum, copper, or cobalt has been successfully topdressed.





RESPONSES

The remarkable progress made in aerial topdressing is a reflection of the dramatic response of both native and sown hill-country grasslands in both islands where clovers are present or oversown.

Native tussock country carrying less than a sheep per acre has been converted into land carrying two and three sheep per acre. Sheep numbers and wool weights have been doubled, while in other cases the poorest blocks have been converted into the best grazing blocks by two and three topdressings of $1\frac{1}{2}$ to 2 cwt. of super and 3 oz. of molybdenum per acre.

On the North Island hill country equally remarkable results are common. Three and four topdressings have converted one-sheep-per-acre hill country to four-sheep-per-acre country. It is estimated, from returns from typical farms, that average pastures carrying one sheep per acre are raised to two-sheep-per-acre pastures, following an average of two applications of 2 cwt. per acre.

Naturally the best responses have been obtained on the more fertile hill country where the pastures contained clovers and English grasses; but clovers have been introduced successfully by oversowing and the better grasses assert themselves as fertility is built up by clovers, phosphate, and animal droppings.

AERIAL FARMING SERVICES

Experience to date confirms the importance of a comprehensive aerial service effectively integrated with the farmers' paddock-to-paddock requirements. The pasture and paddock problems can be partly solved by pilots, planes, and phosphates, supported where necessary with clover and grass-seed sowing, weed spraying, rabbit poisoning, and the dropping of fencing materials.

The demand for suitable aeroplanes to replace the Tiger Moth, which has done most of the work to date, has led to the creation of a specially designed Fletcher Utility aircraft with which it is anticipated even greater progress will be made. This machine complies with the farmers' requirements of a small plane to operate from his strip and become in effect a farm implement for individual paddock service, and which is also safe to fly in hill country with loads up to 15 cwt.

Fig. 6. Topdressing response on native tussock pasture – Parnassus. Half a sheep per acre pasture *(above)* converted to two sheep per acre pasture on adjoining paddock *(below)*.

The dependence on clovers in pastures for effective responses to phosphate makes oversowing with subterranean clover (3 lb. per acre) and white clover (3 lb. per acre) mandatory where clovers are not present, and frequently entails the use of lime or molybdenum to ensure their healthy growth. Clovers must be sown in the autumn in most places and in the spring on South Island high country. Sowing under well-grazed-off conditions, subsequent spelling and moderate grazing are important in ensuring vigorous establishment, growth, flowering, and reseeding during the first year.

The rapid growth of aerial topdressing has been checked by the shortage of phosphate and the unavailability of granular phosphate. However, new fertilizer works and the installation of granulating plant will assist materially in this direction, although our dependence on phosphate made by sulphur processes leaves us at the mercy of overseas exporters. The availability of imported granulated double phosphate at competitive prices on the paddock makes it possible to tide over local deficiencies in manufacture. After the original dressing and oversowing with clovers, the time of application is not nearly so critical, except on soils with high phosphate-fixing propensities. This latitude is important as it tends to spread topdressing over a much longer season and thus meet the requirements of operators, whose operating costs are reduced by longer hours of aircraft utilization.

The control of pasture weeds, such as star thistle, winged thistle, and even gorse, has become an important aerial service on hilly land.

The remarkably effective rabbit-destruction campaign waged by Rabbit Boards can be summed up in two words – aeroplanes and arsenic. The extensive use of light aircraft made possible the efficient and widespread distribution of poisoned baits.

In order to promote a more efficient hill-country fencing system that will keep abreast of the demands made by aerial topdressing, the Council's Advisory Committee on Agricultural Aviation and the De Havilland Aircraft Company have made trials and developed techniques for the bundling and free dropping – without damage – of posts, battens, and wire along proposed fence lines at less than half of the normal transport costs. To meet the modern requirements of hill-country fencing a new light galvanized-steel universal post unit, which can be used in multiples to make angle posts, stays, strainers, and gates, has also been developed to simplify and reduce the cost of fencing.

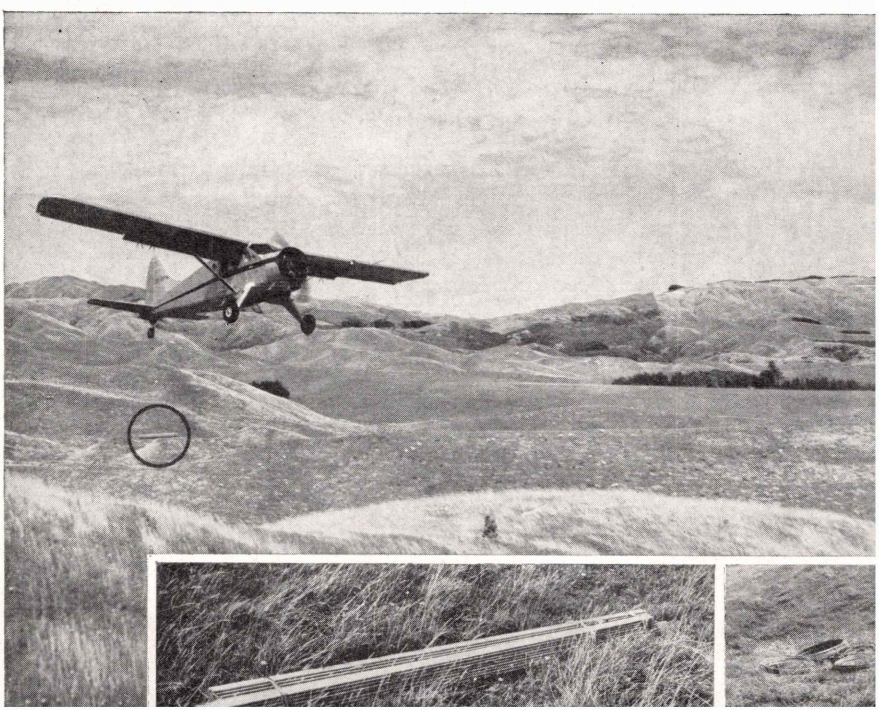
The magnitude of the subdivisional fencing programme can best be gauged by the fact that on average hill country upwards of £10

per acre must be invested in fencing to bring it up to the standard required for the adequate control of grazing on topdressed and improved pastures. It is estimated that there are 15 million acres of native and sown hill-country grasslands likely to need this additional fencing.

The industry has succeeded in developing bulk handling and storage of bulk fertilizers in specially designed storage sheds on farmers' strips, thus reducing the cost and labour in handling and obviating storage at works and subsequent bottlenecks in transport in the season of high demand.

Thus aerial topdressing and related services have a tremendous significance; for when followed up with the necessary conservation-farming practices they make possible the restoration of depleted and eroded hill country.

Fig. 7. Aerial dropping of posts, wire, and battens opens up an important new aerial service to the hill country – Porirua, 1955.



CHAPTER III

Modifying Grazing for Conservation

AS GRAZING IS probably the most important factor affecting hill-country farming, wide modifications in type and intensity of grazing have been used on the Council's experimental and demonstration farms to ameliorate its two most direct effects – continuous defoliation, which weakens most plants progressively, and consolidation by trampling, which impairs the structure of soil.

Experience has proved that modifications in the incidence and type of grazing radically altered the situation and made it possible to change grazing from a destructive to a constructive force – to regenerate run-down pastures, both sown and native, and to maintain others in good condition.

The primary demand of soil conservation is grazing of such a type and intensity that it will ensure the maximum permanent production consistent with the required protection of the soil and control of the rain that falls. To ensure regeneration, reseeding must be permitted, which may involve partial or complete spelling from grazing during recovery until a strong enough sward is developed to give protection and to support production at new and higher levels.

SPELLING

Probably the most spectacular results of all have been obtained by spelling in severe cases of depletion of both native and sown pastures and in cases of serious instability of slopes.

Remarkably rapid recovery of the severely depleted danthonia sward was achieved in this manner at Wither Hills, under a 20 in. rainfall. The spread of existing plants as a result of tillering, and copious reseeding thickened up the sward and revegetated the bare, sheet-eroded patches.

The more dense and rank growth promoted the absorption of water, progressively reduced run-off, and gradually controlled the very active sheet and gully erosion. The reduced and retarded flow of water now clear from grass-covered gullies no longer buries the flats below with silt and shingle or scours away the road half a mile below, as heavy rains did previously.

This recuperative treatment by spelling did not involve complete retirement of the land from grazing – cattle were used after one season to control the roughage and thrived on the forage available because in the better sites improved grasses regenerated more rapidly than danthonia.

Although four-fifths of the farm is steep native grassland and only one-fifth is contoured, the carrying capacity has been raised after a five-year convalescent period from half a sheep per acre to the equivalent of two sheep per acre. Sheep have been reintroduced for two years and the new level of production has been maintained, while the protective, stabilizing, and water-controlling functions of the pastures have been safeguarded.

The efficiency of spelling in providing the initial impetus to improvement by strengthening the grasses and clovers and ensuring reseeding was further confirmed by experience at Tangoio. The initial gains were maintained and became cumulative when supported by subsequent oversowing, topdressing, and controlled rotational grazing with cattle. After four years, sheep were introduced and a narrow cattle/sheep ratio used to hold the gains made at a much higher level of production, i.e., three sheep per acre, as opposed to one prior to treatment.

Remarkable results were obtained by spelling steep, unstable hillsides at Te Weraroa: the weak open danthonia pasture, which provided scant protection and resistance to run-off and soil movement, was transformed in two years to a rank, protective cocksfoot-dominant blanket which increased the stability of the slopes and controlled the run-off. So positive were the effects of this spelling that the original local opposition, which branded spelling as "defeatist", turned to support two years later.

The positive results of spelling in strengthening grasses to provide greatly increased resistance to erosion and conrol of water has also been effectively demonstrated at Ihungia in the East Coast region.

The only access road traverses a saddle between two large steeply graded headward-eroding gullies. The larger and more active gully was acquired by the Council and the Highways Board, and its catchment of 180 acres was fenced and spelled completely for four years. Trees were planted in key places prior to its being seasonally grazed with cattle.

The unstable slopes were soon blanketed with a thick growth of English grasses and some clovers, which combated sheet erosion and rapid run-off.

Gradually the downward cutting of the active gullies lessened with the reduced run-off, and, as a consequence, slip and flow

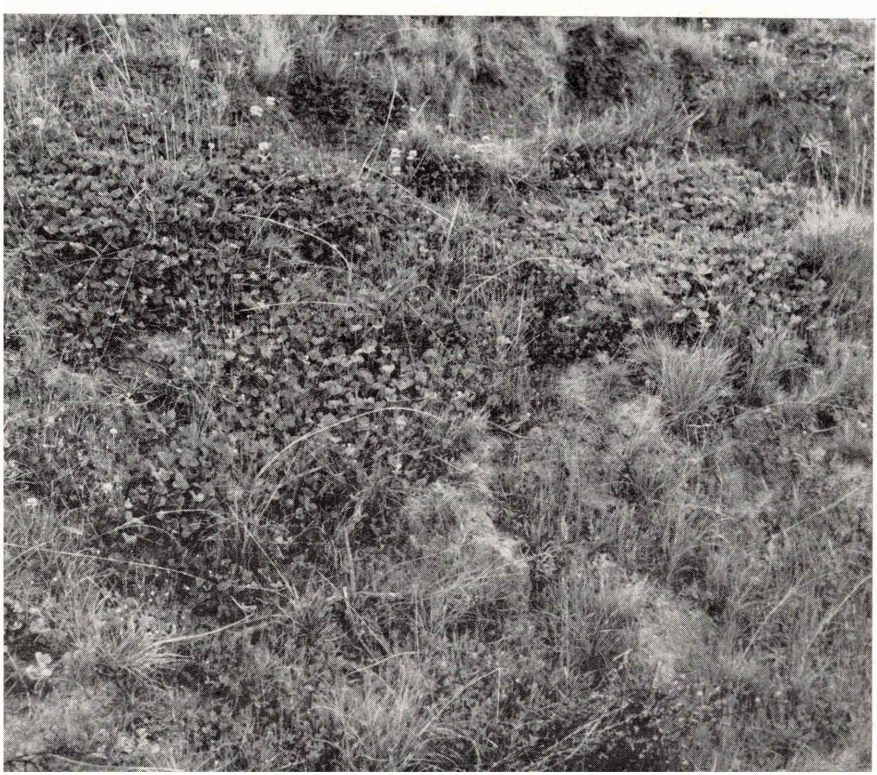
erosion of the sides and heads of the gullies decreased. As the active erosion subsided, revegetation by reseeding increased the cover progressively on hitherto bare gully sides, with the result that the gains have become cumulative and the gully has become virtually quiescent.

Across the road, however, a continued threat develops, despite the fact that several hundred pounds have been spent on debris dams in an attempt to control a similar though smaller gully without disturbing the farmer's normal grazing of the catchment.

Spelling, as illustrated by these widely different cases, has proved that an initial impetus can be given to regeneration of grass that is both practical and effective, and has thus become a constructive first link in adapting grazing practices to meet the needs of soil and water conservation.

CATTLE GRAZING

The cumulative beneficial effects of cattle grazing have been confirmed on the Council's experimental and demonstration farms. The experience of farmers confirms that of farmers in several countries who have used cattle very effectively in reconditioning and maintaining problem grazing lands at higher levels of production.



In the past, the greater use of cattle has been discouraged by the economic returns being lower than those from sheep grazing, while the difficulty of providing adequate supplementary feed for them in lean periods has always been a hazard on hill country. This latter difficulty becomes a positive gain from a conservation point of view as it enforces spelling of blocks or paddocks in rotation for reserves of feed at different seasons of the year and thereby ensures adequate reseeding. It also promotes rooting and greater vegetative protection and infiltration of rain into the soil. The effect of less severe grazing by cattle compared with that of sheep is reflected in the vigour of clovers. In fact, on many soils white clover can be retained in pastures without topdressing if narrow cattle/sheep ratios are used.

The value of cattle in regenerating native pastures in the South Island is being increasingly recognized by leading runholders and their practices conform closely to improved high-country practices developed to combat erosion and deterioration overseas. The striking recovery of native grasslands at Molesworth following the control of rabbits under the recuperative grazing programme of the Department of Lands and Survey is testimony to the value of cattle in such a process.

ROTATIONAL DEFERRED GRAZING

Experience to date indicates that the gains made in increased carrying capacity and in pasture improvement can be not only maintained, but also gradually improved by rotational grazing with cattle and sheep. Subdivisional fencing and improved water supply have made control of grazing with mobs effective, and consequent spelling of paddocks along orthodox lines possible.

Further investigation and trial is required to determine how far rotational grazing and mob stocking with its regular shifting of sheep, particularly during and after lambing, is practicable on the rougher hill country. Since the total weight of wool, lamb, and beef per acre is the criterion, it may be consistent with the best interests to sacrifice weight in individual lambs if more are kept per acre. Whether or not there is a place for sheep at all on the steep and unstable grasslands, which may be suitable for cattle only, has yet to be determined.

Further improvement in grazing management, as indicated by "brake grazing" or "ration grazing" trials, may be possible and practical in the over-all interests of permanence of production on hill-country grasslands as maximum protection would be afforded under this system.

Fig. 8. Management manipulation establishes clovers and grass on hard, sunny, slip-eroded faces at Tangoio.

Trials have shown that the infiltration capacity or rate at which pastures absorb rainfall recovers steadily when stock are moved from them, the combined effect of greater leaf and plant growth along with the removal of consolidation by trampling appearing to account for this.

It is clear that there is an optimum stage of growth at which pastures provide a satisfactory infiltration rate. At this point they can be grazed off quickly to minimize consolidation and spelled to restore infiltration and protection. This conservation aid is possible with rotational grazing and mob stocking but not with set stocking.

Topdressing and oversowing further assist in the matter of protection and water control as the ranker growth of pastures is palatable and still within the control of sheep. Hitherto pastures of lower orders of palatability had to be kept short and sweet for sheep, otherwise they ceased to thrive, and cattle had to be used to clean up the roughage.

Fig. 9. Fire control, seeding, topdressing, and spelling brings white clover into tussock pasture at 2,500 ft. elevation, Upper Waimakariri.

R. D. Dick Photo

SUMMARY

The essential fact about the concept of conservation grazing is that grazing must be adapted to meet a wide variety of needs. First, it must assure the maintenance of an adequately protective pasture for the situation, and, secondly, it must assure as high a level of permanent production as possible.

In unstable and difficult situations only a portion of the annual growth can be taken, otherwise protection and permanence of the sward cannot be assured.

On range lands in Canada and the United States of America it has been found by research into watershed control that it is safe to generalize on the problem country – "take half and leave half", i.e., leave half the total annual growth of herbage for protection and stability.

Obviously in the interests of hill-country grasslands much has still to be determined about prudent grazing for the maintenance of production and the control of soil erosion and flooding.

To this end the Council is prepared to subsidize pound for pound, through Catchment Boards, the cost of materials for new fencing required to control grazing in the direct interests of soil conservation. To date thirty-five miles of subdivision fencing has been erected on this basis.

CHAPTER IV

Using Trees for Soil Conservation

THE PERFECT PROTECTIVE mantle of vegetation afforded by natural plant covering almost completely tempers the force of Nature's twin "sextons" – wind and water, which have buried civilizations in the past – and reduces their effects to a beneficent level as far as soil erosion is concerned.

That trees gave stability to the largest proportion of the country's landscapes in the past and that soil erosion and flooding has been accelerated by attempts to grow grass on increasingly hilly and unstable land has been definitely established.

As the Forest Service safeguards protective forests and has planted trees on a vast scale, the use of trees on farm lands is considered here.

Experience has shown that grass alone is incapable of stabilizing the steeper and more actively eroding slopes and suggests that combinations of grass and trees are required to bring stability to many farmed slopes.

Although the utilization of good land cannot be restricted to tree growing, except for woodlots and shelter belts, the physical and biological capacity of trees to control wind and water erosion demand that a necessary minimum be planted for conservation purposes. Physically, trees break the force of the wind and lower its capacity to blow away soil, intercept and cushion the force of falling rain, and bind or reinforce the soil and subsoil to resist movement; and within a forest they exert a controlling effect on humidity, temperature, and evaporation. Biologically, trees usually improve the structure and fertility of the soil, intercept and bring under their control a high proportion of the rain that falls on it, and promote its better aeration, infiltration, and drainage.

For erosion-control purposes the physical rather than the biological attributes of trees have been put to use, millions of trees having been planted for wind-breaks and large numbers for stabilizing hilly lands against the ravages of water erosion.

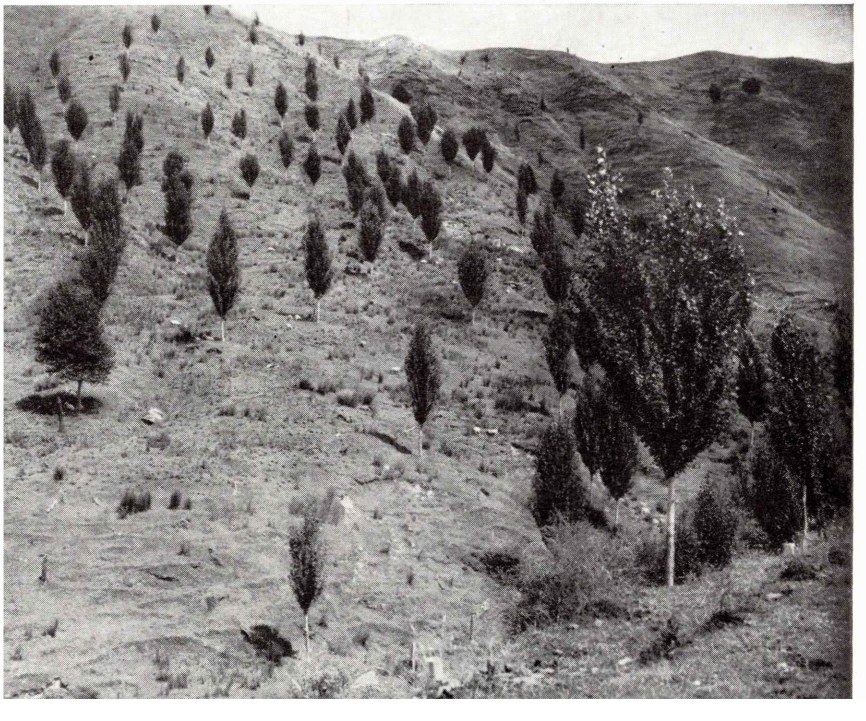
The reduction in stability of slopes formerly held stable by forest but no longer stable under grass is reflected in wind, sheet, slip, flow, or gully erosion and varies according to the slope, soil type, parent soil material, climate, and severity of grazing.

Fig. 10. Pioneering Wisdom – memorial erected by the late T. D. Burnett, on Burke's Pass.

Close examination reveals that the processes of normal erosion have been accelerated and often compounded as a result of the changes induced by farming. The rich absorbent litter has disappeared, the loose springy soil has become compact and structureless, and dries out and cracks deeply in dry weather. On soft mudstone slopes the original pattern of minor gully erosion is changed to one in which the gullies cut deeply downwards to form deep ravines, no longer impeded by the tree roots and logs that formed natural drop structures to dissipate the energy of the run-off. It is evident from the small slip and flow movements that took place in natural forest that the tangled mass of logs moving slowly downwards created natural debris dams that arrested gullying while the bush regenerated. On cleared hillsides by contrast the increased run-off scours away the soil slipping into the gullies, and the slip scars when grazed do not revegetate quickly but erode actively.

The most effective demonstrations of the effects of trees were made by farmers who preserved patches of native bush on steep land, the stability of which contrasted strongly with the cleared land adjoining.

Fig. 11. Planting black poplar to stabilize "papa" hill country – experimental area, Mangaweka.



Conversely, the combined physical and biological influences of trees are effectively shown on steep slopes that have been stabilized by trees after a period of active erosion.

One of the most spectacular examples of planted trees stabilizing eroded slopes is seen on the Gisborne – East Coast highway, where it has been appropriately claimed that the highway is hung on willows and poplars. Until sufficient willows and poplars were planted above and below the highway at unstable points the road slipped downhill regularly – in fact four roads can be seen below one another in some places. Comparatively small groves of willows and poplars have tipped the scales in favour of stability in many unstable sections.

The planted trees bind the soil with their spreading roots, and make it friable and porous, so that it not only absorbs more rainfall, but also through being better drained will not become saturated and liable to mass movement. The improved protection given by trees prevents the soil from drying out and cracking deeply, while the regular leaf fall rapidly builds up a layer of litter and organic matter.

The influence of small groves and even of single trees in counteracting slip and flow erosion on hillsides is commonly observed, and many farmers successfully use willows and poplars to stabilize active slips and unstable portions of hillside pastures.

Willows and poplars planted in gully bottoms, by halting further growth of the gully, have produced a water-resistant network of roots over which water flows harmlessly, and in this way maintain the stability of the slopes above the gully.

More prominent are wind-breaks planted by farmers to protect livestock, crops, and soil from the damaging effects of wind. The countless miles of wind-breaks and shelter belts in Canterbury, Hawke's Bay, and Wairarapa planted by farmers in these arable but windy districts testify to the damage caused by wind erosion when cropping was much more widely practised than it is today.

PLANTING TO STABILIZE HILL COUNTRY

Farmers on unstable hill country have pioneered the use of single- and group-planted deciduous trees, principally varieties of willows and poplars, and their experiences have given a valuable lead.

It has been proved that where grass alone cannot stabilize hill country, planting of these trees in key positions provides added stability sufficient to warrant the Council assisting farmers financially in this valuable work. The Council and the Highways Board

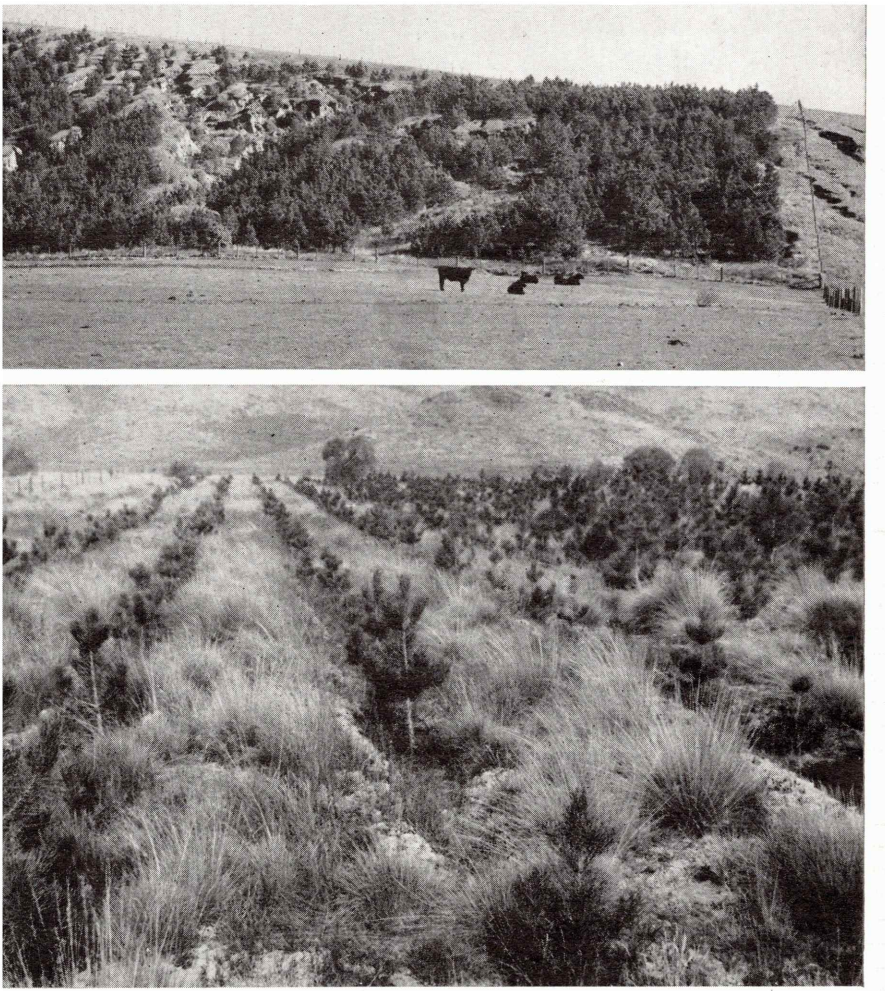


Fig. 12. Planted trees stabilize and reclaim land ruined by erosion – Wither Hills *(above)* Windbreak, well fenced and protected – Tara Hills *(below)*.

have also successfully undertaken extensive closure and planting of steep unstable slopes above and below the highway. Through Catchment Boards the Council subsidizes pound for pound the cost of planting and fencing while the farmer does the work and afterwards maintains the plantations and fences.

The type of planting, as well as the kind of trees and the spacing of them, varies with local conditions and the severity of erosion.

Willows and poplars (black and silver) have proved to be the most popular because they can be planted directly on unstable land by means of long poles that readily take root. Single poles can be protected from stock by binding them with manuka scrub and wire. Such trees are spaced singly or in groups in key places that are unstable or likely to become unstable. The spacing varies from the one extreme of close planting at 8 ft. centres to an average of as low as ten trees per acre, depending on the severity of erosion. The cost of protecting individual trees is justifiably high. The most efficient method is to support individual three-year-old rooted stocks by strong stakes, protect the tree with manuka scrub, and bind the scrub and tree to the stake with barbed wire. As many trees are required, the establishment of nursery areas is recommended so that farmers can cut poles from these stands in subsequent years and thereby reduce transport costs considerably.

To date, subsidy has been granted for 240 tree-planting jobs at a cost of £20,470.

CONTROLLING WIND EROSION

The well established benefits of planting rows of trees at right angles to the direction of the prevailing wind to rob it of its eroding power on arable land are promoted by subsidizing the cost of planting suitable trees and of erecting extra fencing where necessary. Providing that this planting is coupled with adjusted land use – longer crop rotation with topdressed mixed pasture, cross-wind cultivation, cover crops, and possibly trash mulching – much will be achieved in alleviating the problem of direct soil loss and desiccation of the soil during dry windy weather.

In establishing wind-breaks it is recommended that five rows of trees be used, although three rows are popular, and that their establishment and rapid growth be assured by thorough cultivation of the site prior to planting, and subsequent grubbing between the rows during the critical stages of growth. A perfect strike and twice the normal rate of growth in the early stages can thus be assured, especially if fertilizer is used in addition. The variety of trees used depends largely on local experience.

To date seventy-seven schemes for wind-breaks have been subsidized at a cost of £13,763.

Experience and observations confirm positively the value of trees in stabilizing hill country and protecting soil from wind erosion at higher altitudes in windy districts. They are soil-conservation tools that can be used effectively to support other measures in achieving conservation farming.

CHAPTER V

Contouring Promotes Soil and Water Conservation

THE OUTSTANDING EFFECTS of contouring on ploughable land in controlling soil and water losses and increasing production give it significance in a hill-country farming system. Contouring includes cultivation practices following the contour of the ground and the construction of furrows, banks, or terraces as required to control the movement of soil and water and to conserve both.

Although the art of fitting cultivation to the lie of the land by terracing was practised centuries ago in Peru, India, and China, it is now lost in antiquity. Within the last twenty years these practices have been adapted to suit modern mechanized farming. In this short space of time contouring has revolutionized American arable farming. It is making great progress in Canada, Australia, and South Africa because soil and water conservation is directly reflected in increased yields and permanence of production. Contouring and the new system of farming associated with it is proving to be one of the most significant advances in agriculture of this century.

Contouring is based on the simple physical fact that the steeper the slope the greater the tendency for water to run off and carry precious soil with it. The greater the length of the slope, the greater the flow of water and the greater the scouring capacity developed. Contouring seeks to convert these long slopes into short ones by various devices which promote absorption and lead surplus run-off slowly to safe outlets, minimizing run-off and soil erosion. As traditional uphill and downhill cultivation encourages direct flow downhill with maximum losses of soil and water, the most practical way to minimize this effect is to cultivate along the contour. Then every depression made by implements acts as a barrier to this natural downhill movement of soil and water. Contour cultivation can be augmented effectively by furrowing, banking, or terracing to prevent soil erosion. These structures are made on the true contour or are graded according to whether they are required to promote absorption of water or partial absorption and diversion of excess water safely from slopes.

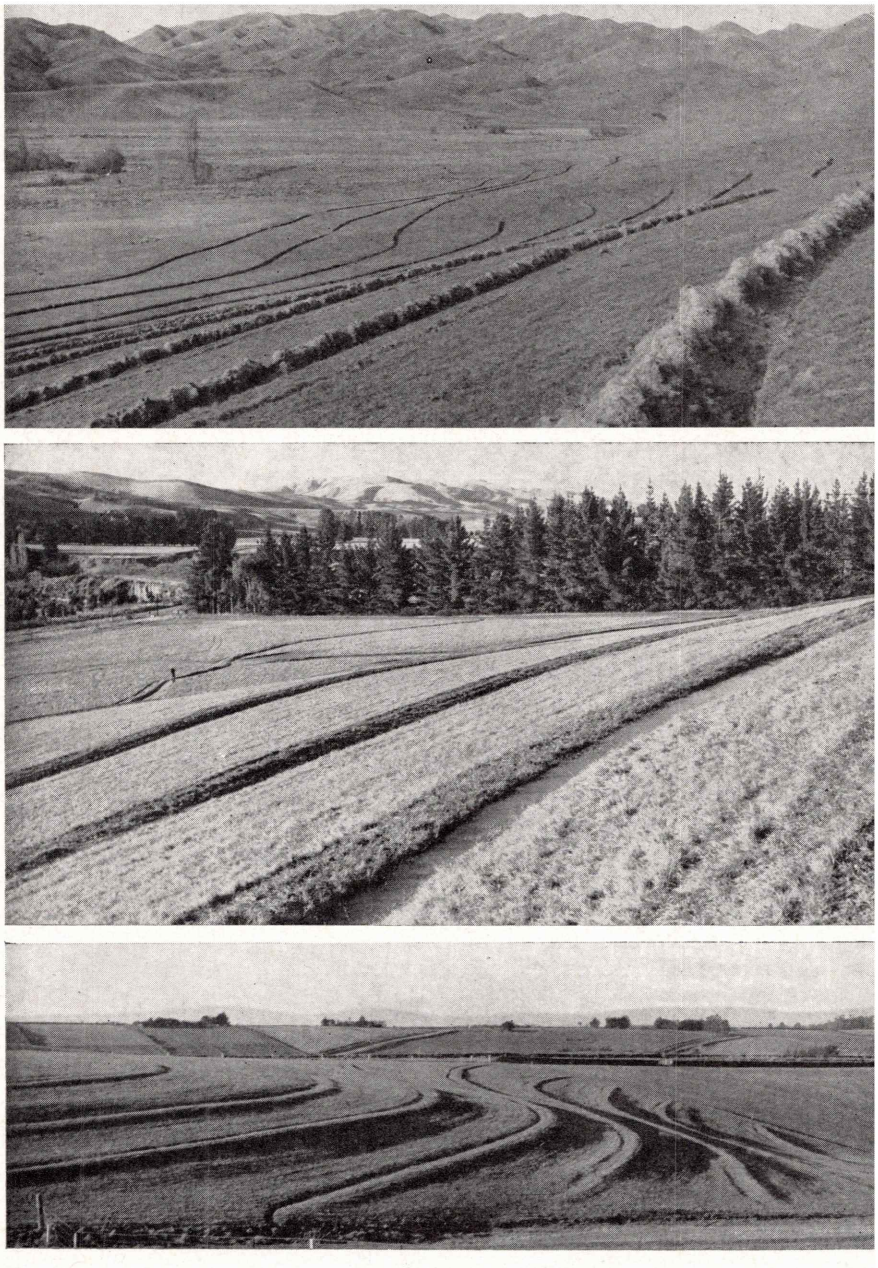


Fig. 13. Pasture furrows prevent run off, promote absorption and improve distribution of water on hillsides – Hakataramea *(above)*.

Contour banks are similar to, but are level and have a larger capacity, than these graded banks – North Canterbury *(centre)*.

Graded banks promote absorption of water and carry off surplus water slowly and safely *(below)*. Adair, South Canterbury.

PASTURE FURROWS

The simple and inexpensive device of ploughing a discontinuous furrow across the slope of the contour, or a continuous furrow at a slight gadient across the slope to lead off surplus water slowly, has proved to be widely useful in this country.

In the many practical trials arranged with farmers these furrows have established their water-conservation value by maintaining a more even greenness on the slopes during dry weather. By acting as drains and controlling water in wet weather pasture furrows have solved the baffling condition called "poaching" which is aggravated by modern intensive stocking of high-producing pastures having low resistance to trampling. Keeping more water on the steeper slopes by promoting absorption where it is needed reduces seepage to the lower, gentle slopes and obviates wet, boggy conditions conducive to the growth of rushes.

Well made pasture furrows on hilly country in Nelson, Marlborough, and north and south Canterbury have effectively brought sheet and rill erosion under control on newly sown pastures, while the additional water absorbed gives rise to bands of greener, stronger grasses and clovers above and below the furrows. They have been used effectively in leading water away from wet depressions and using it to advantage on the drier parts of slopes as well as in preventing saturation of the gentle slopes beneath, and may be used effectively over a wide range of slopes from the ploughable limit of 20 degrees down to very gentle slopes of 5 degrees. Experiences to date show that pasture furrows at 6 ft. vertical intervals provide adequate control of run-off on pastures with average slopes. The distance between furrows ranges from 20 to 30 ft.

To date the Council's Mobile Works Unit has treated, at the request of farmers, 4,316 acres.

CONTOUR BANKS

Contour banks or mounds are larger than pasture furrows, have a greater holding capacity, and are primarily used to promote absorption of water. As they are effective at greater distances apart than furrows, they are more suitable for cultivated land. They have been used successfully at Wither Hills, where newly sown pasture, after 7 in. of rain in one week, was so soft that one sank to the boot-tops near the banks, but they held, and permitted no loss of soil and water from 15 degree to 20 degree slopes. Contour banks were also tried in Central Otago, where maximum storage of water was necessary, but, owing to the combined effect of high-intensity

rains and loosely worked soil which washed into the channels and so reduced the much needed storage capacity, they were only partially successful.

Experience indicates that this possible combination of circumstances makes it prudent to use graded banks in preference to contour banks, unless the latter are of adequate size and the soil is protected by pasture or crop.

GRADED BANKS

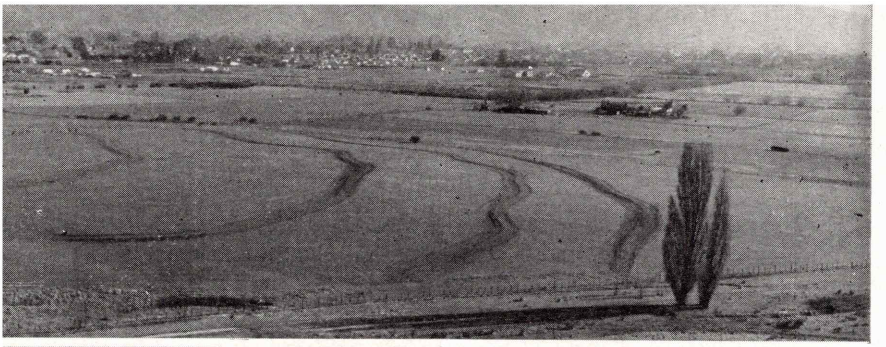
Graded banks have been extensively demonstrated with considerable success on arable land where the slope is too great (above 7 degrees) for broad-base terraces. These banks consist of several furrows moulded to make banks big enough to provide an effective channel above them which collects surplus water and carries it across the slope at a gentle gradient ($\frac{1}{2}$ to $1\frac{1}{2}$ per cent) to a safe discharge outlet.

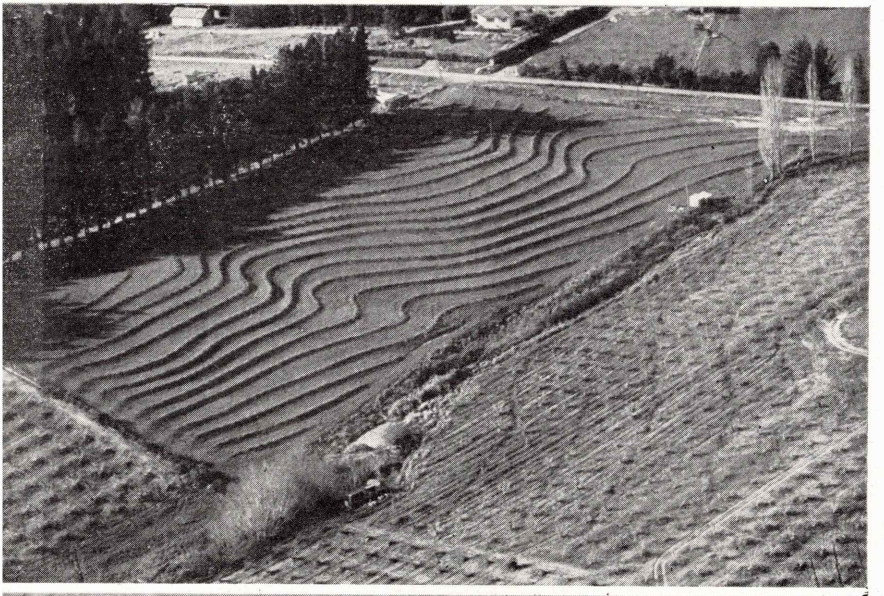
These channels with their supporting banks are arranged across the slope at 8 ft. vertical intervals where it is estimated, from the slope, climate, and soil type, that excess water will begin to flow and carry soil with it during heavy rains. Before it has gained momentum this excess water is led across the slope at an increasing gradient to cope with the increasing flow as the area drained enlarges. These banks must be accurately graded, otherwise they cause a concentration of water which scours severely if the banks are broken. In practice they have proved to be effective over a wide range of conditions in the South Island in controlling sheet erosion and run-off and increasing crop and grass production.

A combination of graded banks, contour cultivation, and crop rotation has been used effectively on a property leased by the Council at Gibbston and on its property at Adair to restore severely sheet- and rill-eroded worn-out crop land. So successful was the first crop of ryecorn, which was intended for a trash mulch crop, that it was harvested, and the 60 bushels per acre virtually paid for the original and subsequent recuperative conservation treatment on the area at Gibbston.

Graded banks controlled run-off and soil loss so effectively at Adair that fertility was rapidly restored to normal levels on the treated paddocks, while pasture production was 30 per cent higher on treated than on untreated slopes in an adjoining paddock.

To date, the 1,984 acres treated by arrangement with farmers indicates the demand that has been created by successful demonstrations.





BROAD-BASE TERRACES

The nation-wide modern practice of broad-base terracing on the gently sloping arable lands (up to 7-degree slope) in the United States has been one of the greatest modern adaptations introduced into farming to combat extravagant soil and water losses and to increase production. These terraces are designed with a wide (20 to 30 ft.) gently graded bank which, although it has a large-capacity, shallow channel above it, is no hindrance to modern implements. Such a bank thus meets the requirements of a bank that will break up long slopes without physically impeding cultivation.

Just as this practice forms the basis of a new arable farming agriculture overseas, indications from trials are that it is just as likely to do so in this country, particularly if cropping is extended in future. The protective, fertility-building pastures on arable land mask the urgent need for terracing in this country except in areas of low rainfall where water conservation is critical.

Broad-base terraces with a gentle gradient to remove excessive water were constructed along the easy slopes on an overcropped farm in Marlborough to prevent water from above collecting in the depressions. The crop of peas that followed yielded over 50 bushels per acre and was the first successful one for five years.

Several positive trials in north Canterbury have established the fact that broad-base terracing promises to play an important part on the gently sloping, highly productive arable land.

The area treated, 442 acres, indicates that farmers are recognizing the potentialities of this new practice.

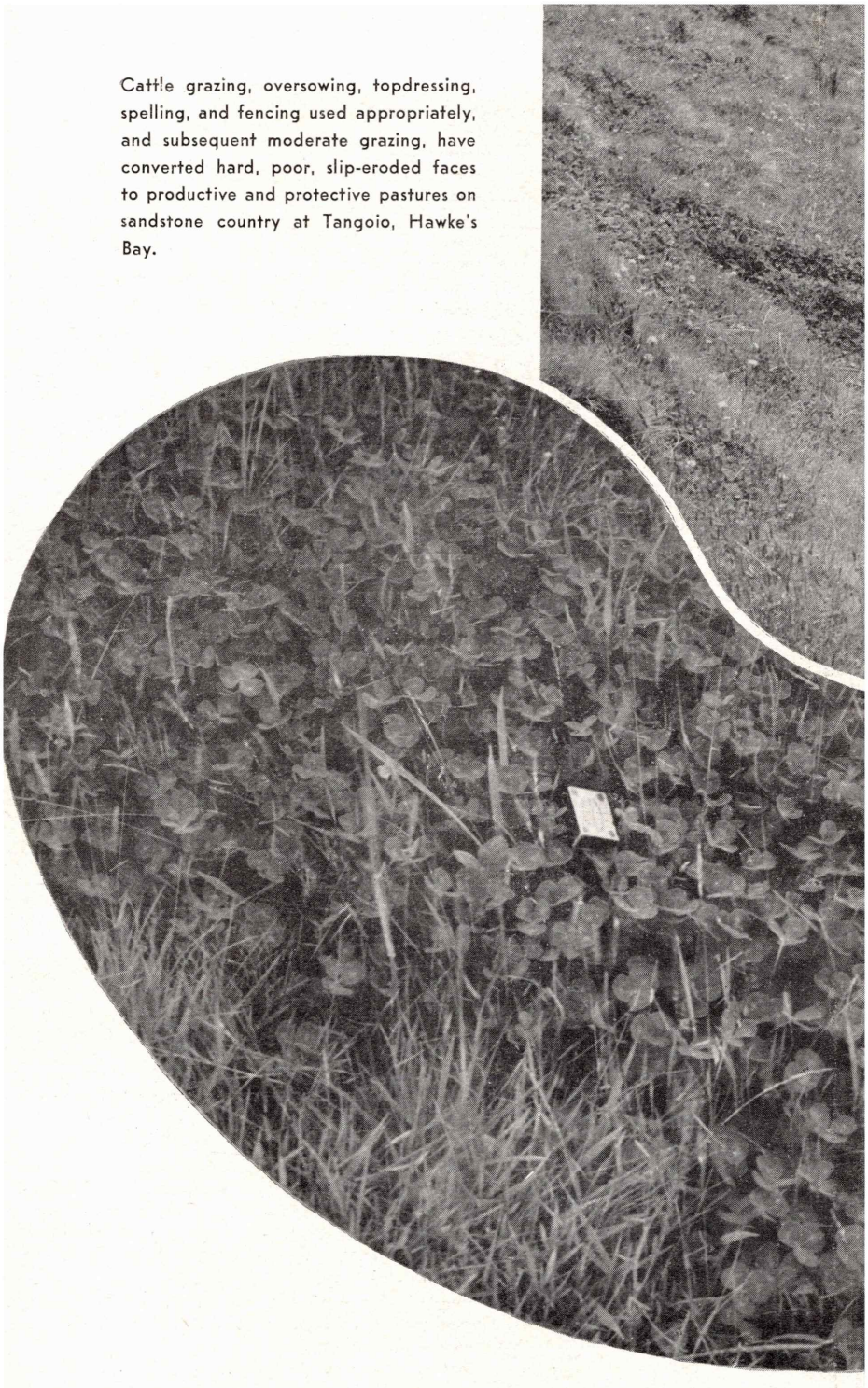
DIVERSION TERRACES OR BANKS

These terraces are specially mentioned, though similar in principle to those above, because they have a particular place over a wide range of conditions in New Zealand. Such a terrace or bank must be fairly substantial as it has to make provison for a large channel above it which may drain excess run-off from large areas of land too steep to contour. The special situation requiring these substantial channels is at the change of slope between steeper pasture land and ploughable land below an area that is frequently subject to seepage and suffers from poor drainage. If cultivated, the lower

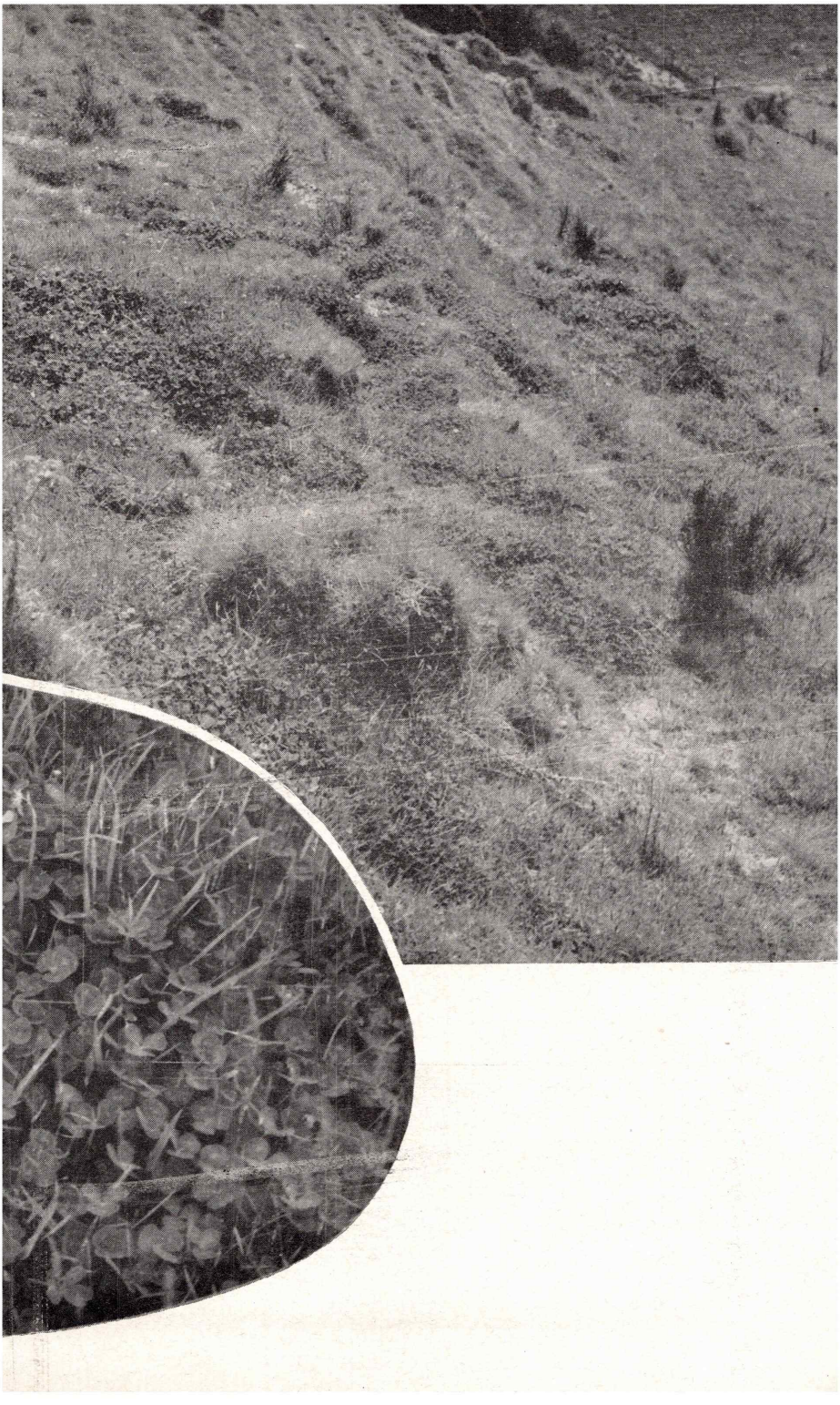
Fig. 14. Broad base terraces on more gentle slopes control run off and soil loss and can be readily negotiated by farm implements owing to the width and gentle side slopes of the bank and channel above it – Blenheim *(above)*.

Bench terraces minimize run off and soil loss on steep orchard land – Nelson *(centre)*.

Soil and water control on varied slopes of a small catchment: by pasture furrows (left), graded banks (right), broad base terraces (distance), and stock pond (centre) *(below)*.



Cattle grazing, oversowing, topdressing, spelling, and fencing used appropriately, and subsequent moderate grazing, have converted hard, poor, slip-eroded faces to productive and protective pastures on sandstone country at Tangoio, Hawke's Bay.



slopes are likely to suffer from overflow from the hills above causing rill and gully erosion. In North Canterbury several diversion terraces have been constructed that have successfully protected the ploughable land below against the run-off from extensive, poorly grassed slopes above.

Banks up to 4 ft. in height and 12 ft. in width provide a channel up to 3 ft. deep at the middle and 15 ft. in width and meet the requirements of large areas from which run-off is rapid.

BENCH TERRACES

Bench terraces are best known in the older countries of the world, where they have made permanent farming on rolling to steep slopes possible. The tremendous labour involved in making these bench terraces and supporting banks (rock or vegetation) has restricted this practice to lands where labour is plentiful or where there is a dearth of flat land.

However, the modern bench terrace is developed much more cheaply by using the normal cultivation and soil-movement processes to build the bank gradually. On some steep, badly sheet-eroded orchards in Nelson where up-and-down slope cultivation was physically impossible, across-the-slope cultivation between the rows had naturally created bench terraces some 4 to 5 ft. in height.

On slopes above 7 degrees in Nelson graded banks or terraces have been constructed and young fruit trees have been planted along these banks, which have definite channels above them, some 3 ft. wide and up to a foot deep. Excess run-off collects in these channels, and that which is not absorbed flows off slowly. Subsequent cultivation and cover cropping builds up fertility and causes movement of soil into this channel. The bank is thus gradually built up to form a bench terrace. The steep lower slope of the terrace is stabilized by clover, grass, or lucerne.

Bench terraces of both types have been successfully made on orchard lands in Nelson and Canterbury.

CONTOUR CULTIVATION

Contour cultivation is an important supporting practice to terracing owing to the fact that the various cultivation operations create small depressions across the slope which impede the downhill movement of soil and water.

Contour cultivation, even without terracing or banking, is a worth-while practice, especially if grubbing or disking instead of ploughing is adopted, and is most effective during the short periods between crops in reducing losses of soil and water.

STRIP CROPPING

Strip cropping fits in very readily with any contouring work and further reinforces the benefits of terracing or banking as crops drilled along the contour provide greater resistance to the flow of water and the movement of soil.

As protective close-growing crops, such as grasses, cereals, and fodder crops, can be alternated in strips with open-growing crops, such as potatoes and swedes, the surplus run-off from one can be absorbed by the other below. The crops can also be alternated to ensure that no two strips are lying fallow simultaneously.

Strip cropping has been widely used in Canada and the United States for the control of wind and sheet erosion. On slopes too steep for mechanical terracing of any kind, strip cropping has come into its own as the most important special practice available and is still more effective when assisted by fertility-building crop rotations and pastures.

The limited trials undertaken in this country indicate that strip cropping supported by long pasture rotations will help considerably in solving the problems of excessive run-off and soil loss on sloping land.

GRASSED WATERWAYS

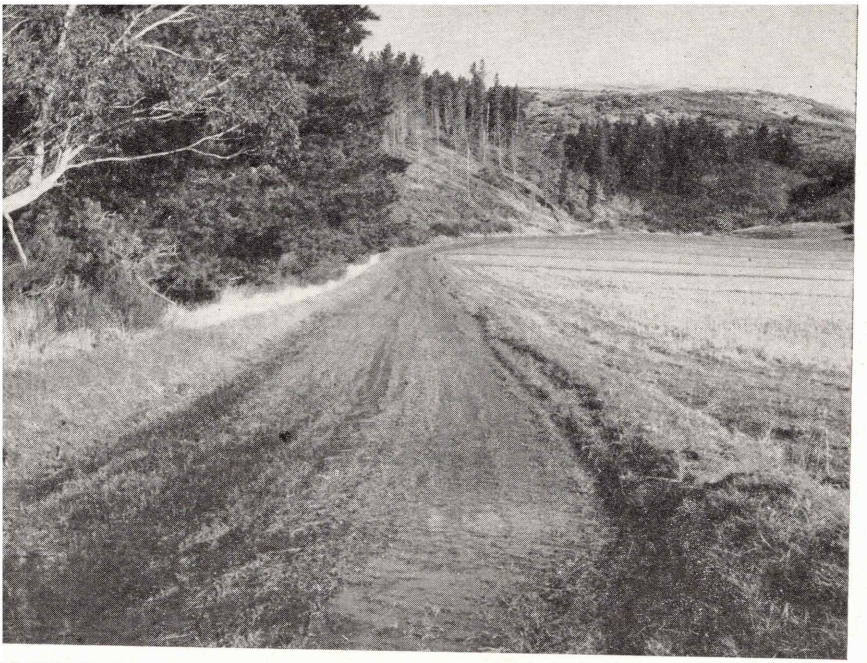
The safe disposal of excess water is of prime importance in all contouring systems, and adequate provision is made in the planning stages for the effective disposal of surplus water to natural waterways. Experience in this country already confirms overseas experience that wide, gently sloping grassed waterways can be fitted into each scheme to connect the terrace, furrow, and graded bank outlets with natural waterways.

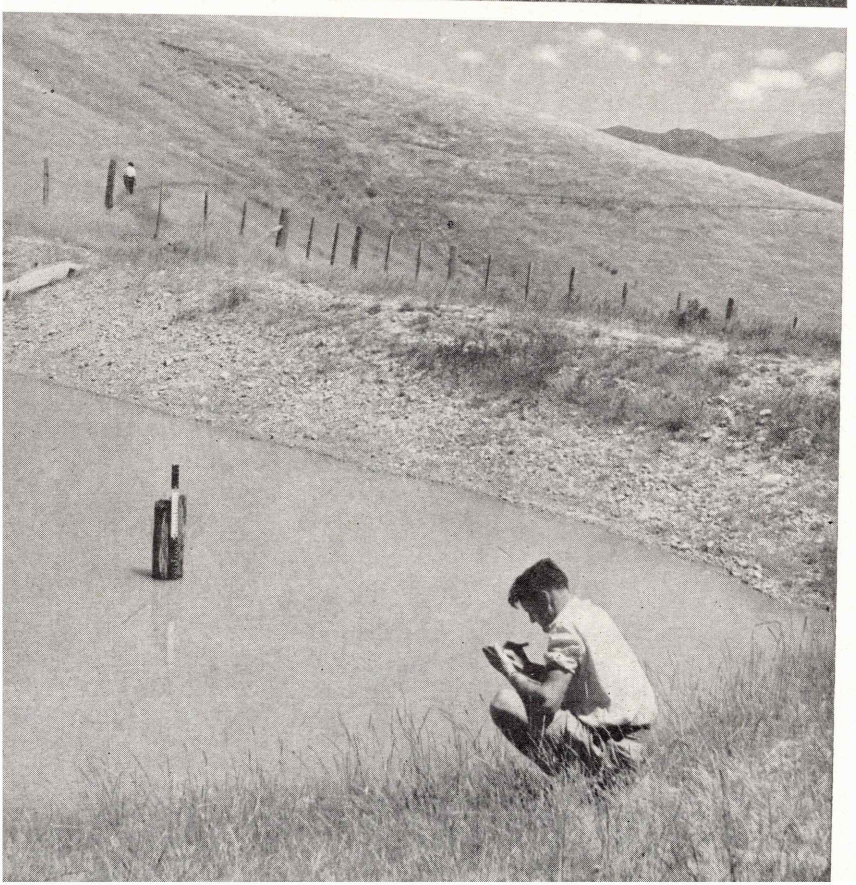
Before the terraces or banks are constructed these waterways must be surveyed, graded, and sown to turf-producing pastures in order to avoid scour resulting from concentrating the flow of water. Waterways must be graded accurately and made wide enough to ensure that the water is spread evenly over a wide channel (1 ft. in width for each acre of catchment).

STORING AND USING SURPLUS WATER

Contouring and the resultant improved vegetative cover is the first phase of more efficient conservation and use of water.

The second phase consists of impounding and storing the controlled run-off in stock ponds, discharge regulating dams, and reservoirs for stock water, irrigation, and fire fighting.





These harmful flood-producing flows are "harvested", stored, and put to use as the most valuable commodity in dry seasons for controlling fire and sustaining production from parched lands and thirsty stock.

Flooding is such a serious hazard in practically all catchments owing to the hilly nature of most of the land and the likelihood of intense or long-duration rains that all land must be made to absorb, retain, and retard the flow of water to reduce the peak flooding lower down. This is the essence of the most practical and efficient system of flood control, and materially assists in reducing the cost and maintenance of the necessary structures required in the lower river systems. Gully, stream, and river erosion are serious and wasteful consequences of excessive run-off that can be reduced considerably by regulating the discharge of water from the land. The costly effects of drought can be largely offset if adequate provision is made for the storage of water for livestock, while on many farms advantage can be taken of natural facilities to store sufficient water to irrigate at least part of the farm, thus obviating the adverse effects of dry spells.

STOCK PONDS

Stock ponds can be distributed regularly over the farm to advantage and should be sited on safe locations, preferably on small flats and in depressions on the hills. The size depends on the rainfall, the number of stock to be watered, and the size of the catchment. It is preferable to site them away from existing gullies which drain large areas, concentrate flow, and make the provision of safe overflow difficult.

Excavation of a storage pond on a flat site in a saddle on the hillside requires little banking and provides a wide grassed overflow lip that will prevent scour, while the water entering the pond is governed by the area of catchment from which the run-off is "harvested" by a graded bank leading into the pond. Such ponds should be as deep as possible to reduce evaporation, and should be fenced from stock and the water piped to troughs. If the subsoil is porous, trampling by livestock and the use of clay usually seals them. To date 47 stock ponds have been made by arrangement with farmers for these purposes.

Fig. 15. Grassed waterway on gentle gradient carries off surplus water efficiently from the outlets of graded banks (upper right); North Canterbury *(above)*.

Stock pond, high on the hillside, supplied by a diversion bank from the slope above – Marlborough *(below)*.

DISCHARGE REGULATING DAMS

Many of these are sited near the heads of natural depressions and gullies, and where a minimum of excavating and banking is required. The fill must be thoroughly compacted on the exposed firm subsoil, be of adequate width, and have a properly installed discharge pipe at a certain level with provision for a safe discharge to prevent erosion by the flow from the pipe. It is also necessary to provide for excessive flood flows over a wide spillway to one side of the dam on to a grassed slope.

RESERVOIRS

Reservoirs with several acre-feet capacity augment stock water supply, and each acre-foot provides sufficient water to irrigate on the average 1 acre of pasture land. Such reservoirs should be sited in natural swampy depressions on upland valley floors where the gradient is low and the width sufficient to provide inexpensive storage, as the fill required is relatively small. Alternative situations are provided on terraces or lower flats where water from a gully or grassed waterway can be diverted along the contour to the excavated reservoir well clear of the natural gully and stream. When it fills sufficiently, in-flow ceases and little provision is necessary for overflow.

The advantages of siting these reservoirs above the land to be irrigated or supplied with stock water is that sufficient "head" can be obtained to give the pressure required for sprinkler irrigation, otherwise the water must be pumped under pressure.

SUMMARY

Experience with the above special soil and water conservation practices, one or more of which can be adapted to the requirements of all ploughable land, has already established their ability to control both soil and water movement, this control being reflected in increased crop and pasture yields.

The most significant contribution to date is the response of pasture land to contouring. Improved water control on hilly pastures increases protection and production, sustains growth in dry seasons, and avoids poaching of the soil in wet weather. Poaching is intensified by heavier stocking and by the weak turf of modern high-producing pastures.

Still more complete conservation of water by impounding run-off as a flood-control measure and using the stored water for livestock, fire control and irrigation, bids fair to become both popular and profitable with the advent of sprinkler irrigation.

CHAPTER VI

Fighting Gully Erosion

TACKLING THE INSIDIOUS PROBLEM of gully control with engineering and soil-conservation techniques has been a prominent feature of the Council's conservation work on erodible hilly country.

The desire of farmers and Catchment Boards to grapple with the problem provided the opportunity to promote further interest in soil conservation by subsidizing farmers prepared to help themselves. This led to direct action and a fuller realization of the basic fact that the eroding gully is a symptom and a result of the more deeply seated combination of causes. The simple cause – increased run-off resulting in greater scouring capacity by the surface water – has been aggravated by concentration of the flow by consolidation and trampling of soil, and by excessive cultivation.

A new authority is usually faced with a local demand to cope with the worst situations first, and is very often stampeded into doing so regardless of the magnitude of the job and the benefits likely to accrue, while the much less spectacular but equally important preventive work at the incipient stages in neighbouring areas is forced into the background. This to some extent has happened here. The experience gained, however, has been invaluable in developing methods for controlling gully erosion and has much in common with experiences in Europe, America, and Australia.

ACTION TAKEN

The action taken in gully control has had to resolve a variety of problems ranging from simple gullies on cultivated slopes and incipient gullying on fairly stable country to severe gullying on steep hill country underlain by highly erodible sands. The rapidly developing, deep ravines in much shattered, rotten, mudstones and sandstones quickly bring about the collapse of entire upper catchments.

As the means of coping with many of these problems were well beyond the resources of the farmer, and as much of the gullying adversely affected river conditions lower down or interfered with road access, assistance by way of subsidy was graduated from three to one to one to one, largely according to whether or not large

structures were required. Local materials and facilities were used as far as possible, and every attempt was made to use suitable vegetation (grass, trees, and shrubs).

The Catchment Boards in the North Island have been most concerned as the position is serious on highly productive land, particularly in the Poverty Bay Catchment District.

To date, the gully-control schemes tackled have cost £46,000.

CONTOURING AND ADAPTED FARMING PRACTICES

Gully and rill erosion of steep cultivated slopes has been successfully arrested by pasture furrowing in the simplest cases, where excessive run-off gullied newly sown pastures. The results obtained have been extensively applied on downland country in north and south Canterbury and in parts of Otago by the Council's Conservation Works Unit and by Catchment Boards.

On cultivated land, graded banks and subsequent contour cultivation and improved crop rotations, including pastures, have not only solved the problem, but have also created a growing demand by farmers for this class of work. This has resulted in the Council's staff planning the work and running the levels while the farmer uses his own equipment to construct the banks and carry out later the necessary contour cultivation. In special cases where gullying of cultivated slopes was caused by water coming from above or outside the area treated, diversion terraces have been used to lead the water safely to natural channels or grassed waterways.

CONSERVATION GRAZING OF CATCHMENTS

Gully and rill erosion on unploughable steep grassland has also been tackled successfully by recuperative spelling and subsequent moderate grazing of the entire catchment affected. This has been effectively done on badly gullied steep country under both the low-rainfall, natural grassland conditions of the South Island at Wither Hills and the high-rainfall, severely gullied conditions of the North Island at Ihungia in the Poverty Bay district.

The rank grass, by promoting infiltration of rain, improving soil structure, and offering resistance to the flow of water, slows down run-off and spreads it over a longer period, thereby reducing its eroding power. The spelling and lighter grazing encourages natural seeding and the spread of grasses on to the actively eroding slopes. Because such treatment involves temporary and partial retirement of affected land it is not popular, and will have to prove itself more economical in the long run than the more direct, expensive methods

Fig. 16. A combination of well managed pasture and trees planted in the gullies of catchments minimizes gully erosion – Poverty Bay.

that farmers are naturally tempted to use. Coupling these experiences with other more direct methods tried, will, no doubt, provide the best solution to the problems.

Direct methods of gully control, using a variety of structures, combined with pole planting of rapidly establishing trees, have led to an ingenious array of techniques to cope with the varied problems which are of considerable local value.

PAIRED PLANTING

In the simplest case paired planting of willow or poplar poles at key points at 10 to 20 ft. intervals along the sides of incipient gullies has proved to be effective, as the roots grow towards the water thus providing an erosion-resistant mattress that prevents downward and lateral erosion by the water. These poles are firmly planted at 2 ft. 6 in. to 3 ft. in depth and are protected from stock damage by binding manuka scrub round them to a height of 5 ft. Many examples of this type of planting in the past have prevented the downward development and widening of gullies in the sections treated.

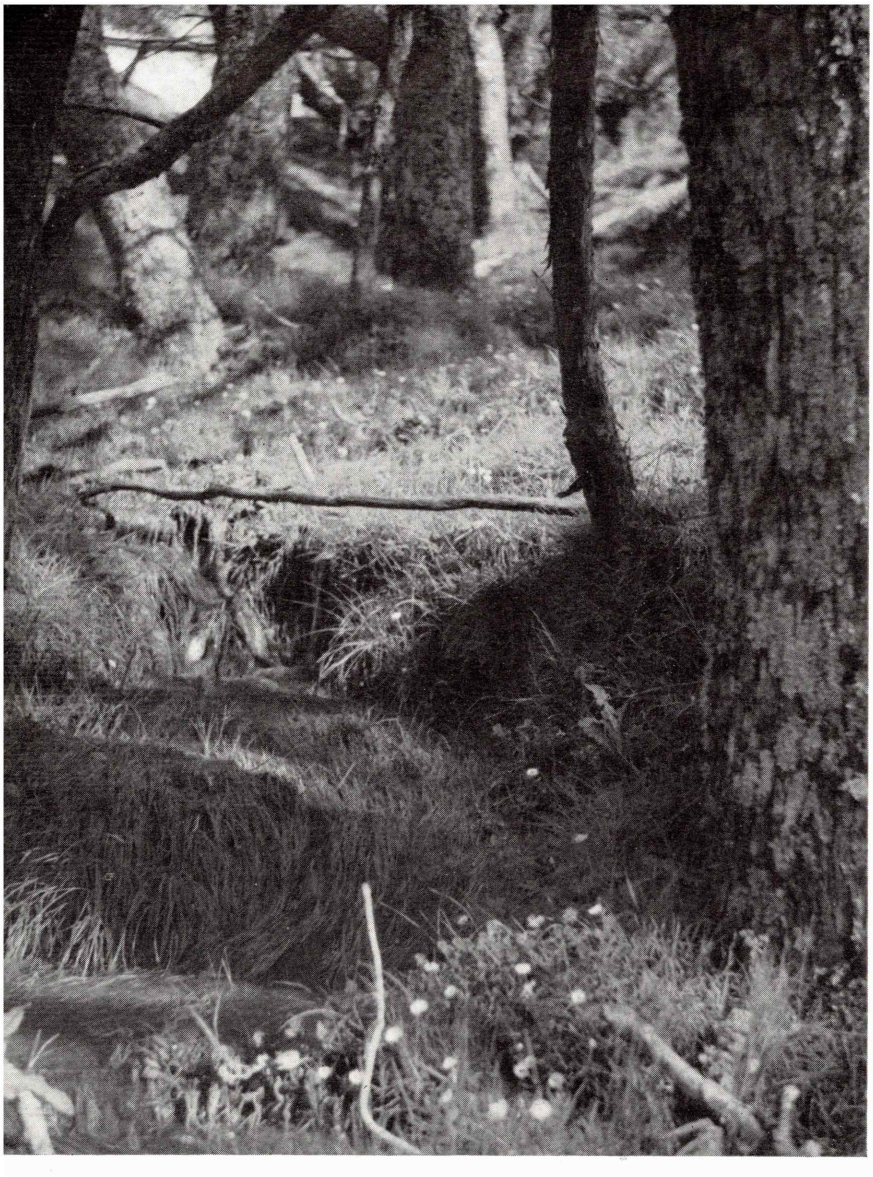


Fig. 17. Paired planting of willows has effectively stabilized the gully and water flows over a mattress of willow roots and grasses – Poverty Bay.

DEBRIS DAMS

A variety of types of debris dams has been developed to meet the many kinds of conditions found. They met with varied success according to the severity of the gullying and the treatment of the upper catchment.

SLAB AND LOG DAMS

Slabs and logs have been used effectively to prevent scour, accumulate debris, and provide drops to lessen the erosive force of flood waters. These have been augmented with willow and poplar poles which have rooted extensively at the dam site and will take over the work of the structure as the log materials decay.

WIRE NETTING AND LIVE POLE DAMS

Two main types of netting and pole dams have been developed to cope with large quantities of debris on the move on gully floors.

In Poverty Bay the Catchment Board's engineer has developed live pole and netting dams placed in the wider portions of gully floors consisting of a curved row of stout poplar and willow poles (bulging downstream) supported by a steel cable firmly anchored in both banks. Bundles of manuka are pegged down across the gully and secured to the steel cables. They trap silt and debris effectively. When the live poles are firmly established wire netting is placed on the upstream side of the poles. Rubbish collects in the netting and aggrading takes place rapidly until the dam is full. When this has been effected a second curving line of poles is established on the upstream side of the dam and a further length of wire netting used to obtain another accumulation if required.

The other North Island Boards have developed a different method of placing the poles – pairs of live poles are used to make an X-frame which is used to support the wire netting that collects the debris, while scrub is used to prevent scour and undermining of the structure. These relatively cheap structures have proved to be effective in many situations.

PERMANENT MATERIALS

Masonry dams are not used as there is rarely local stone suitable for the purpose. A small number of concrete dams have been used where gullying affected roads.

Experience with structures in which trees are used has brought to light the importance of adequate maintenance, which should be

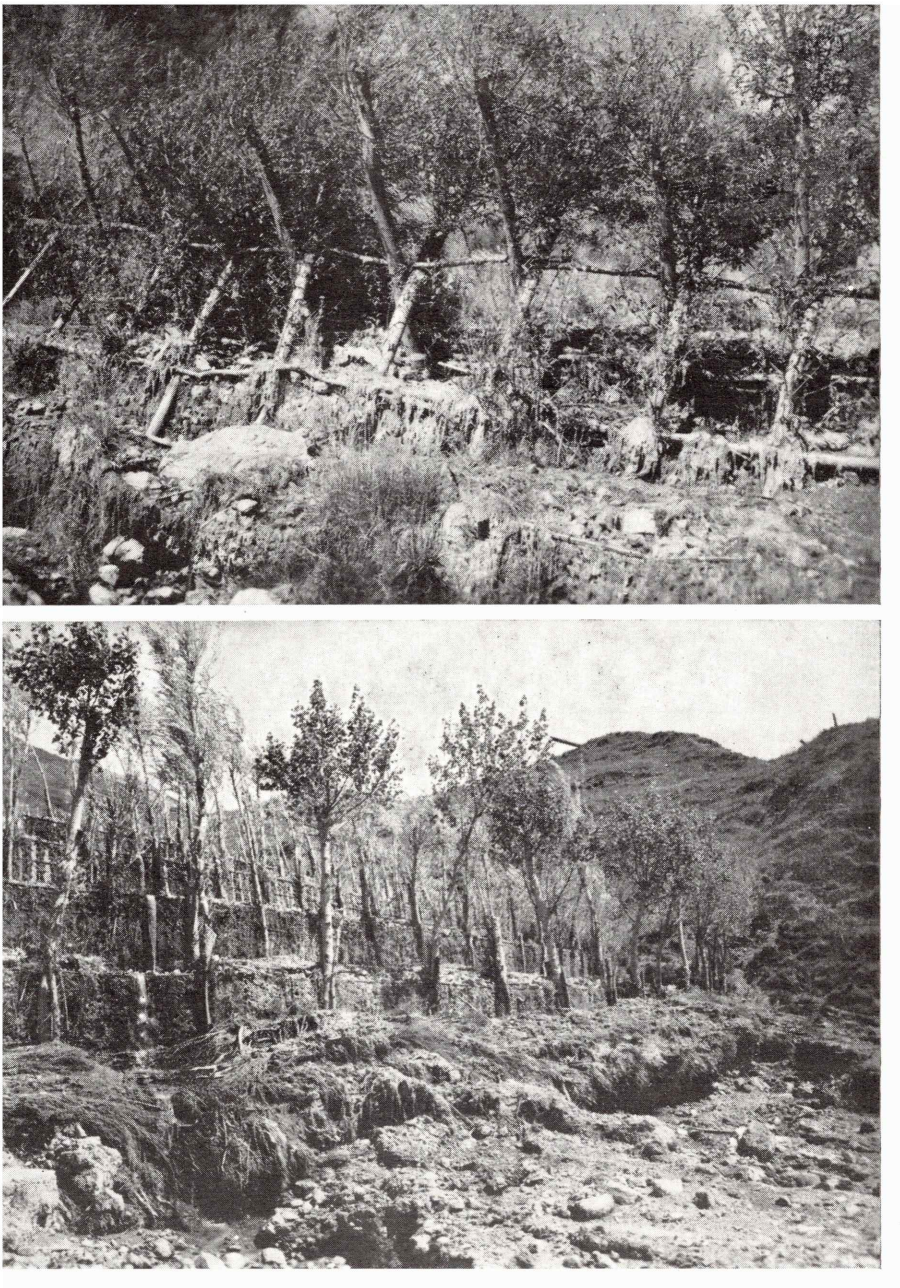


Fig. 18. This Willow X frame, netting, and manuka scrub debris dam has halted erosion – Wairarapa *(above)*.

Willow pole, post, cable, netting, and manuka scrub debris dam used with considerable success by Poverty Bay Catchment Board *(below)*.

provided for in the original cost of the job. Maintenance requirements are high owing to the physical damage sustained by trees (barking and breaking in floods), the unstable nature of the country, the killing of trees by opossums or domestic stock, and by salts in certain mudstones.

SUMMARY OF GULLY CONTROL EXPERIENCES

1. Contouring practices have provided practical control of gully and rill erosion on rolling ploughable slopes. Pasture furrows, graded banks, contour cultivation, strip cropping, constructive crop rotation, and topdressing of pasture in the catchments of gullies have been effective when used in various combinations.

2. Spelling, fencing, topdressing, and oversowing, coupled with subsequent moderate cattle and sheep grazing and judicious tree planting, have provided effective relief to gullying on unploughable native and sown hill-country catchments in both islands in sufficient trials to warrant extended use of these practices.

3. Preventive planting of paired poles and spaced planting along the banks of incipient gullies, together with moderate grazing, is a promising control measure in preventing the widening and deepening of existing gullies.

4. The extremely hazardous nature of the problems tackled with structures has naturally resulted in several failures, study of which provides valuable information on which to base future works. It is obvious that the load these structures have to bear must be relieved as much as possible by appropriate supporting conservation practices in the catchments concerned.

5. Where possible, diversion of the water, or of portion of it, temporarily or permanently, and retention of it by discharge regulating dams, contour banks, and pasture furrows should be used to support an improved grass cover and appropriate tree planting.

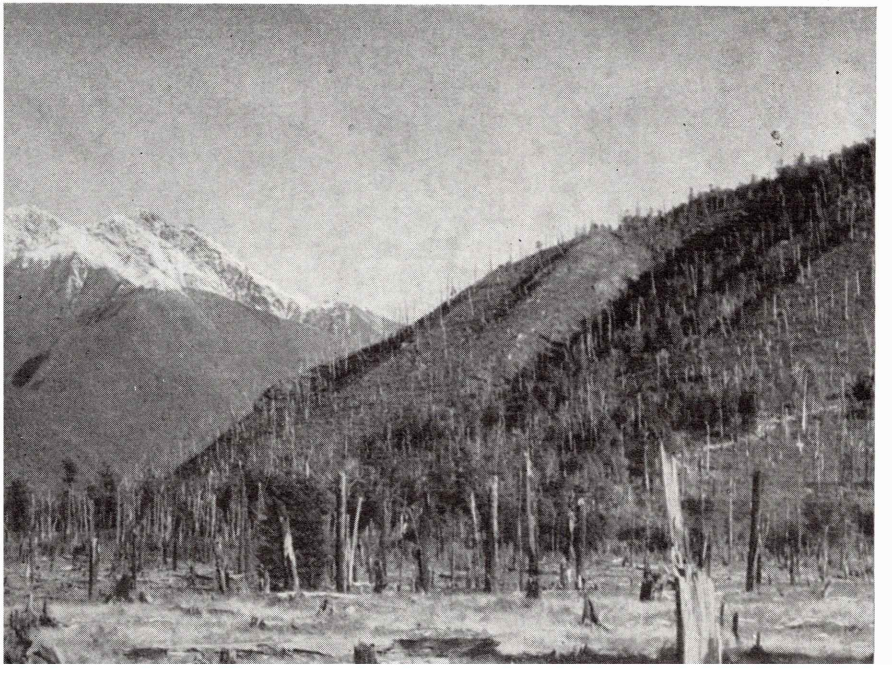
6. Experience indicates the desirable trend in our thinking and action towards comprehensive conservation and engineering measures over the entire troublesome catchment rather than concentrated effort in the gully where symptoms only can be treated. In effect, gully control becomes minor-catchment control.

CHAPTER VII

Controlling Fire and Pests

ALTHOUGH FIRE FORMERLY PLAYED a useful part in disciplining the wilderness and winning farm land from the scrub and forest lands, it had long been used excessively on natural grasslands. Regular burning of native grassland due to a misinterpretation of its effects had grown to be a traditional management practice, but coupled with the effect of heavy grazing by sheep and a plague of rabbits it accelerated the normal erosive processes of Nature and resulted in millions of acres of grassland being converted into virtual desert.

The Soil Conservation Act outlawed uncontrolled burning; and in the greater interest of protecting soil and vegetation, permits to burn, have to be obtained from Catchment Boards. Although in itself a seemingly negative measure, the control exercised became the first constructive and positive step in relieving the country of the effects of this most destructive practice. Burning of the residual vegetation, after grazing by sheep and rabbits, denied the soil even small increments of protective and soil-building plant residues, with the result that decline in fertility and loss of structure of the soil were continuing to make it an easier victim of erosion.



This initial conservation measure was further supported by the Forest and Rural Fires Act, the express purpose of which is to safeguard life and property, including especially forests, crops, and pastures, in periods of extreme fire hazard.

Catchment Boards have brought by-laws into operation which make it obligatory for farmers to obtain permits for burning throughout the year. It is thus possible to limit necessary burning to restricted areas and to periods of the year when the soil and lower portions of the grasses are damp and fire is least injurious. Provision is made for combating accidental fires by the development of fire-breaks in natural locations and the organizing of fire-fighting equipment and personnel. The beneficial effects of fire control combined with spelling, cattle grazing, oversowing, and topdressing have been most spectacular in the regeneration of both native and sown pastures on the Council's farms as well as on numerous privately owned farms.

A constructive alternative to burning has thus been made available as a new technique in catchment control.

PEST CONTROL

Rabbits

It was early apparent that no progress could be made with conservation of much of the native grassland country while it was heavily infested with rabbits, and consequently the Council actively supported rigid control measures which culminated in the Rabbit Destruction Act.

The Rabbit Destruction Council, operating its decommercialization and killer policy through Rabbit Boards, has had remarkable results in controlling rabbits, its performance being comparable with that for the elimination of sheep scab in the 'eighties. With the virtual elimination of rabbits it is most urgent that farmers should follow up this excellent work with oversowing, spelling, and moderate grazing practices so as to revegetate depleted land and restore it to former levels of production – levels unknown to the present generation of farmers. Hakataramea Station has been enclosed with rabbit-proof fencing and rabbited effectively for over forty years. The striking contrasts in the vigour, density, and carrying capacity of the pasture on this run with that of adjoining land has to be seen to be believed.

Fig. 19. Rigid control of fire is urgent on poor unstable uplands in many catchments – Tophouse, Nelson.

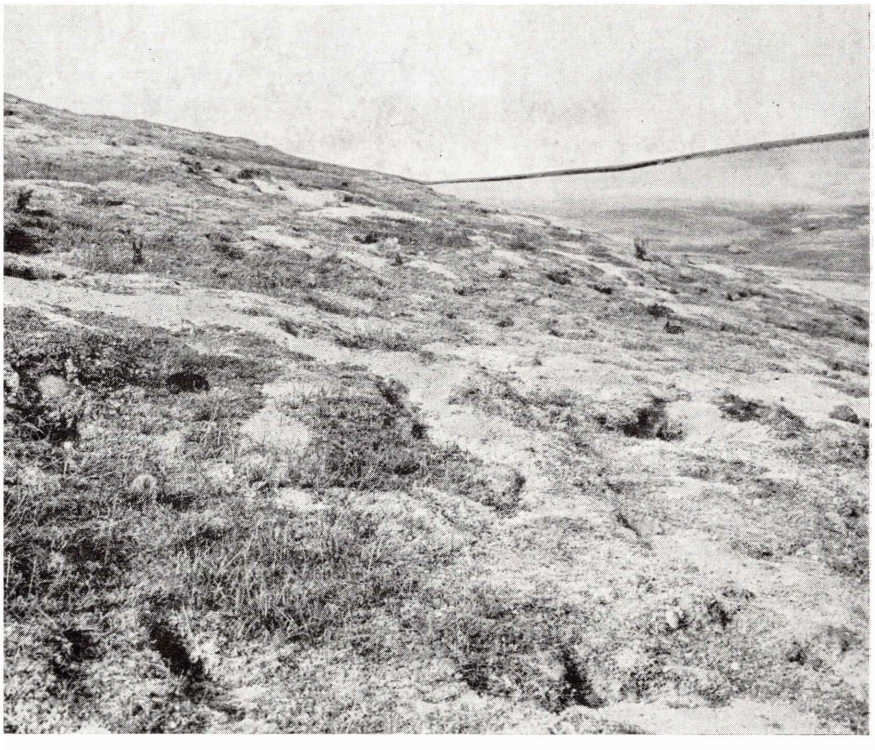
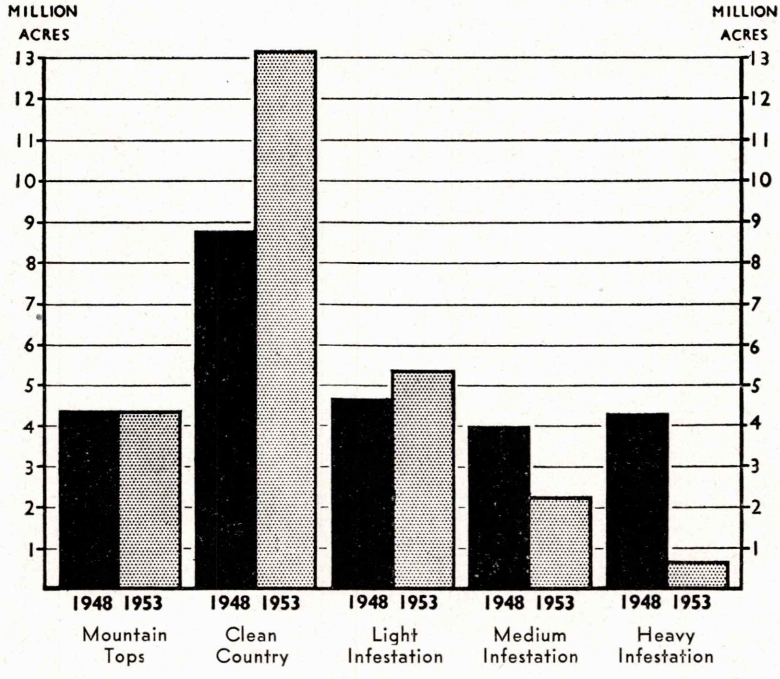


Fig. 20. Ruin by rabbits – nothing short of complete extermination will satisfy farmers and Rabbit Boards.

The Rabbit Destruction Council is well on its way to retrieving the several million pounds worth of annual pastoral produce hitherto denied to the nation by that verminous luxury, the rabbit, and is rapidly reducing its destructive influence on both vegetation and soil.

On Te Aka Station the control of burning, and more recently the control of rabbits, has been followed up by aerial topdressing with 150 tons of super and light seeding with cocksfoot and clovers with the result that the wool clip has been increased from 100 to 210 bales. This remarkable response on 18 in. rainfall country was accompanied by greatly increased lambing percentages and a substantial decline in mortality. The Rabbit Destruction Council's experience emphasizes the urgency to complete the coverage of all rabbit-infested areas by active Rabbit Boards to make systematic eradication possible and minimize reinfestation of adjoining areas cleaned up at considerable cost and effort. Constant vigilance on apparently rabbit-free areas by farmers and Boards is equally urgent if the permanent benefit from the million-pound annual

Graph comparing Rabbit Infestation in 1948 with that in 1953 in the area covered by Rabbit Boards



investment in rabbit destruction is to be obtained, and to ensure that there shall be no future devastating plagues of rabbits to do irreparable damage to the pasture and soil resources of this country.

Opossums

Owing to the direct destruction by opossums of trees planted to control soil erosion in the Gisborne district, the Council was instrumental in getting the protection removed from this vermin that threatened forests as rabbits did the grasslands. The removal of protection, the good price for skins, and the 2s. 6d. bounty on tokens has resulted in upwards of one million being destroyed last year. There is, as yet, little positive evidence indicating a decrease in the population, nor can too much be expected of a commercialization policy which in principle cannot be effective in controlling a noxious-animal population. To date, the most critical feature of their depredations is the defoliation and killing of trees planted for erosion control and the killing of existing exotic and native trees. The depredations in native forests have in a few places reached

Fig. 22. "I'd have that bit too, if I could reach it!"
Opossums increasingly threaten planted trees, and native forests. Willow almost killed by defoliation – Waimata, Poverty Bay.

serious proportions, and their ultimate effect cannot be forecasted until more information is available from surveys and investigations.

Deer

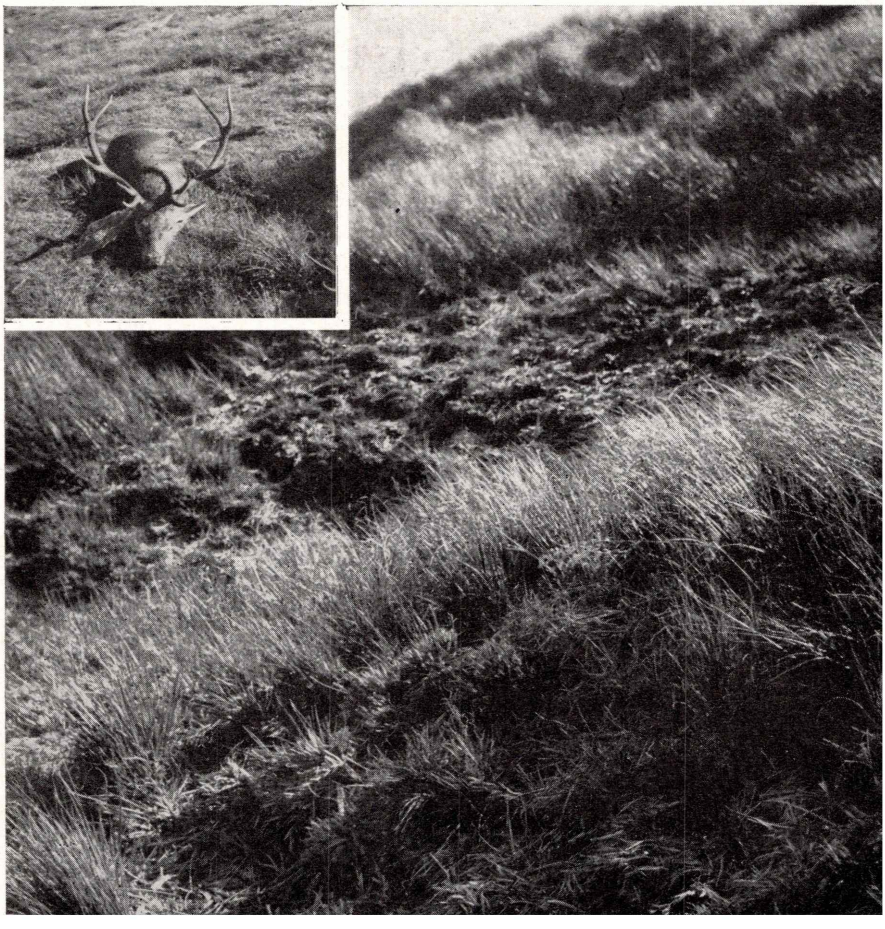
Deer have been liberated so widely in the past that there are few protective forests and alpine lands in the upper catchments of the troublesome rivers that are not occupied by deer. Public interest has been sufficiently strong in support of culling and control of deer that the Department of Internal Affairs has been able to sustain an active shooting programme employing well over one hundred shooters. Despite the difficulties the Department has destroyed over half a million deer to date on some of the most difficult country

in the headwaters of our rivers. It estimates from the export of skins that private shooters have taken twice as many deer, to give the imposing total of two million destroyed in New Zealand since 1930. The policy of shooting where the best tallies can be obtained has been modified to one of concentrated shooting in areas considered most critical by the Departments directly interested in land.

As the price of skins has dropped, the trend towards a policy of decommercializing and killing is thus becoming effective in deer control. This, however, has been recently threatened by attempts to establish an export industry in deer meat.

Indications are that the build up of deer and opossum populations is such that a policy comparable with that of rabbit control – killer and decommercialization – will be necessary using aircraft for large-scale distribution of suitably developed poison baits.

Fig. 23. Protective snowgrass above the forest at 6,000 ft. destroyed in patches by overgrazing by deer in a critical part of a high rainfall catchment – Paringa, West Coast.



CHAPTER VIII

Developing a Conservation Farming System

SUITABLE COMBINATIONS of the foregoing conservation farming practices have been applied successfully to several eroded hill-country farms acquired by the Council.

Early investigations revealed that the existing method of farming on hilly lands was the major cause of erosion and the resultant flooding because it was not adapted to the needs and limitations of the land as were the practices on the more stable and fertile areas.

It was necessary to devise practical ways of stabilizing the soil and controlling run-off, and at the same time develop farming practices which would enable a farm to be operated at a profit. Accordingly, experiment and demonstration farms of a size corresponding to the average size of local holdings were placed under recuperative management using a combination of prudent-farming and soil-conservation practices.

Fig. 24. Contoured and improved pastures on lower slopes, regenerated native pastures on upper slopes – Experimental and Demonstration Farm, Wither Hills, Blenheim.

WITHER HILLS EXPERIMENTAL AND DEMONSTRATION FARM, MARLBOROUGH

This farm of 440 acres of severely sheet- and gully-eroded, low-rainfall hill country, virtually abandoned owing to depletion of pastures and soil erosion, was acquired in 1946. Spelling the sparse native pasture to regenerate it by reseeding, and control of burning and rabbits together with progressive tree planting of land ruined for agriculture, was the practical plan adopted by the local advisory committee. Spelling promoted revegetation of the bare land, and was further accelerated by generous reseeding, but, as the fire hazard increased, cattle were introduced after the first season to control the roughage.

The more vigorous grasses were grazed on the more favourable sites. Progressively, paddocks were fenced and supplied with water from farm ponds where possible. In the worst gullies debris dams were installed for trial purposes.

The diskable and ploughable lower slopes were contour cultivated, and pasture furrowed or contour banked as the slope dictated, and mixed pasture was established after fallowing, liming, and topdressing. Aerial topdressing and seeding of steep slopes was also undertaken. Sheep were purchased later and run to advantage with cattle on this dry native grassland as supplementary feed became available on the improved, contour-banked pasture paddocks. Sheet and gully erosion, so prevalent on adjoining land, has been brought under control by the thick thatch of regenerated native grasses and by contouring of the lower slopes.

The general transformation of this farm from an abandoned actively eroding condition to a stabilized productive condition by drastic but simple practical conservation farming methods is reflected in the fact that it now carries two sheep to the acre (equivalent) instead of one sheep per 2 acres originally. This land that has been brought back economically to a permanently productive condition is typical of thousands of acres of problem land in the district. More important still, it no longer menaces highly productive land on the flats below with flooding and burial by sterile debris.

TANGOIO EXPERIMENTAL AND DEMONSTRATION FARM, HAWKE'S BAY

At Tangoio 500 acres of severely slip-eroded, steep hill country was part of a larger area acquired in 1949 for stabilization of the notorious Devil's Elbow section of the highway fifteen miles north of Napier.

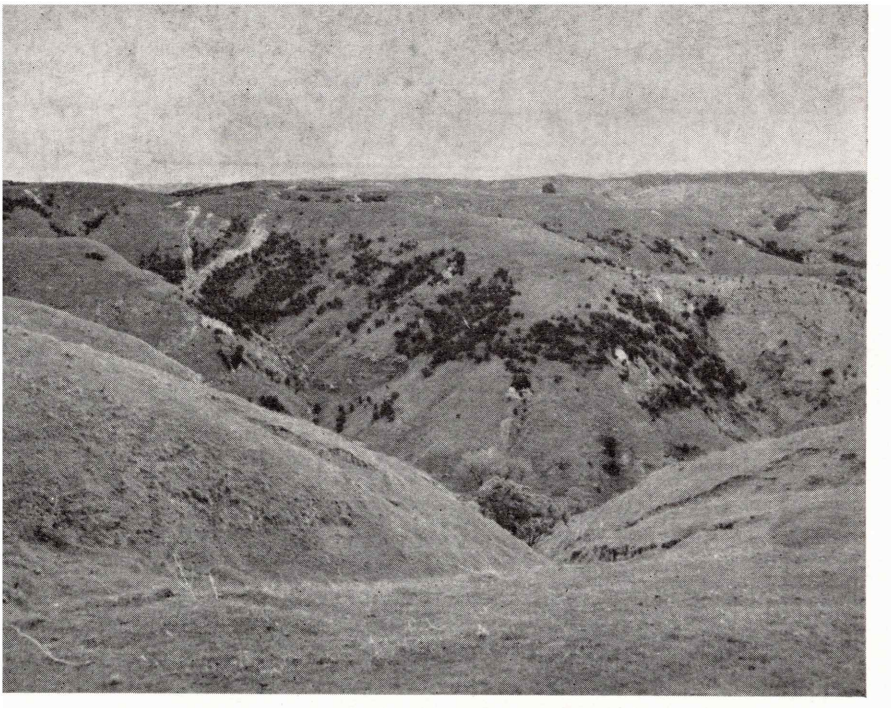


Fig. 25. General view of Tangoio Experimental and Demonstration Farm – Napier in distance, Hawke's Bay.

The depleted pastures were predominantly danthonia, while the very broken country was seriously slip and gully eroded, on northerly aspects particularly. The farm was spelled during the first season to increase pasture protection and encourage reseeding on the poor pasture and slips. Following this, 160 head of cattle were grazed for some months to control the roughage prior to oversowing with subterranean and white clover and topdressing with superphosphate. Fences were repaired, water supply was improved, more cattle were purchased, and rotational grazing was practised. Cattle did well, and topdressing was continued at the rate of one bag per acre in succeeding years. After four years sheep were reintroduced, and a narrow sheep/cattle ratio has been maintained subsequently.

Not only have clovers been successfully introduced to these danthonia pastures, but English grasses have also asserted themselves on the more favourable sites.

Slips have been clothed, or partially clothed, and stabilized by both native and English grasses and clovers. Planted trees have been used extensively to stabilize steep slopes on land adjoining the highway and to a limited extent on the farm itself. Constructive

management has been achieved by spelling, subdivisional fencing, cattle grazing, topdressing, oversowing, and rotational grazing with a narrow cattle/sheep ratio. This limited combination of practices has raised the carrying capacity from one sheep per acre to the equivalent of three sheep per acre, lifting the farm from a marginal economic level to a positively economic level. The key to establishing subterranean and white clover on the steep eroded slopes has been hard grazing and trampling by cattle prior to oversowing and topdressing in the autumn. This was supported by subsequent spelling until the clovers were established, with moderate cattle grazing and spelling during the flowering and seeding period to ensure copious reseeding of the established clovers.

WAERENGA-O-KURI EXPERIMENTAL AND DEMONSTRATION FARM, POVERTY BAY

One thousand acres of fairly typical steep mudstone hill country fourteen miles west of Gisborne was acquired because the area was suffering from severe slip, flow, and gully erosion that threatened the highway in several places along the frontage.

Fig. 26. General view of Waerenga-o-Kuri Experimental and Demonstration Farm showing terrain – Poverty Bay.

The property is traversed by a highly fractured and crushed shatter belt, through which a deeply entrenched valley is actively undermining slopes and rapidly eroding headwards owing to artificial diversion of water from a catchment of 900 acres. On the two-thirds of this farm that forms the steeply sloping unstable sides of this valley grazing pressure has been relieved largely by spelling, and trees have been planted copiously to assist the remnants of native bush to stabilize the slopes. On the remainder of the farm topdressing and oversowing, subdivisional fencing, drainage, ploughing, and pasture establishment have been undertaken and a narrow sheep/cattle ratio used. Gully-control work was done with indifferent results because of the abnormal flow that had been diverted into the main gully. Experience proves that the only practical method is to divert portion of the catchment run-off into the original stream, contour the remainder of the catchment, install a discharge regulating dam and drop structure at the head of the gully, support this with debris dams in the lower gully, and plant the steep eroding gully sides with willows and poplars.

The over-all result of the combined measures to date is that the stock-carrying capacity of the farm has been doubled, and at the same time the grazing pressure on the steeper eroding slopes has been relieved to utilize the maximum protective and stabilizing effect of grass and trees. Here again, badly eroded land has been tackled in a practical way with a combination of farming and conservation measures with satisfactory results in the first phase. Further investigation and measurement of the effectiveness of individual practices is a necessary second phase to determine more precisely the value of each conservation practice.

ADAIR EXPERIMENTAL AND DEMONSTRATION FARM, SOUTH CANTERBURY

This property of 134 acres of exhausted sheet- and gully-eroded downlands five miles from Timaru was acquired to measure and compare the effects of modern contour-farming practices with normal practices.

The problems of excessive run-off and soil loss, along with fertility exhaustion and weed invasion, were tackled with a combination of good farming and special soil-conservation practices. As far as possible pairs of paddocks were treated identically as far as crop rotation, lime, fertilizing, and grazing were concerned, and varied only with respect to cultivation. Normal up-and-down cultivation was practised on one, and contour cultivation coupled with graded banking was practised on the other.

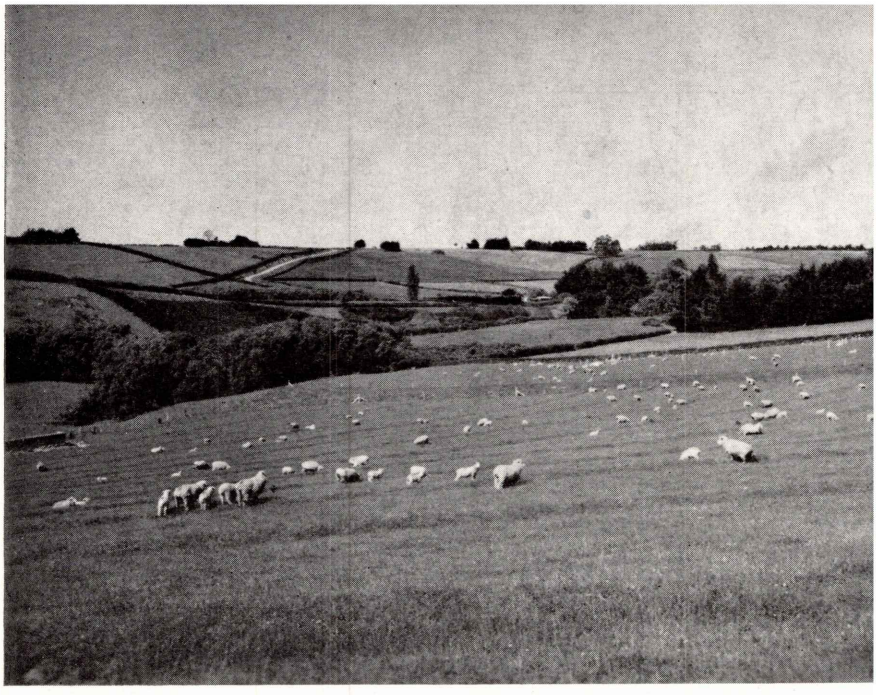


Fig. 27. Adair Experimental and Demonstration Farm showing contoured pasture with normal pasture in background – South Canterbury.

The first significant result was the complete control of sheet and rill erosion coupled with retardation of flow of surplus water and greater absorption of it in the gently sloping channels above the banks. This was in sharp contrast to the marked sheet and rill erosion and excessive run-off from the adjoining paddock which was cultivated in the normal way. These effects were most apparent during the cultivation and fallow period between crops and in the establishment stage of the succeeding crop.

A striking contrast between the contoured paddock and a neighbouring one was revealed after 2 in. of rain – 3 ft. of soil filled the depression below the up-and-down cultivated paddock while there was no sign of soil loss from the contoured paddock.

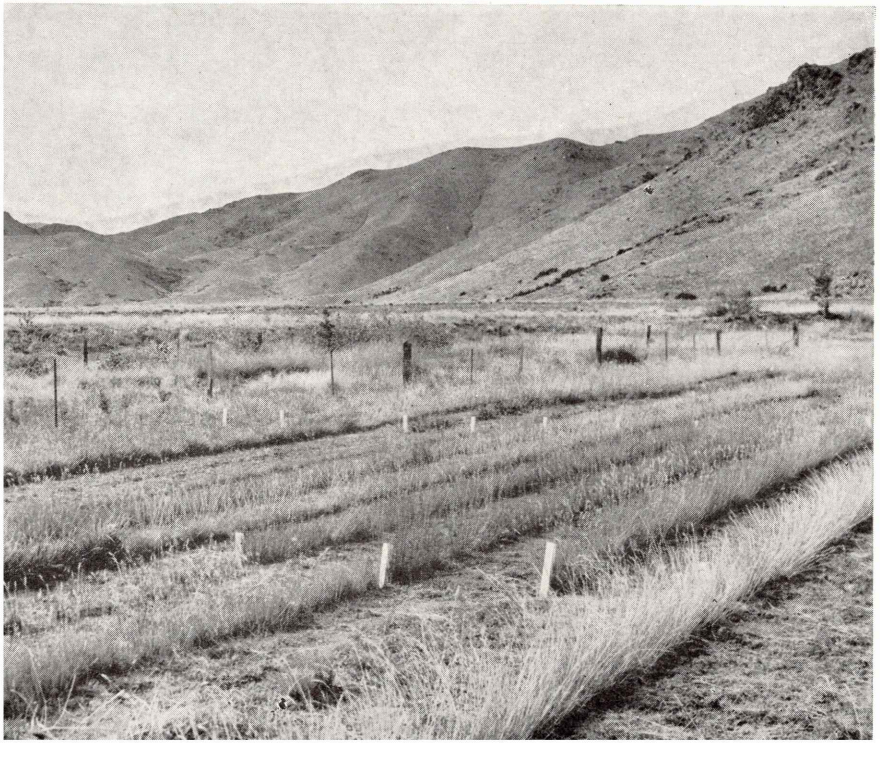
Fertility was rebuilt remarkably quickly on the contoured paddocks, the comparative improvement being reflected in a difference in yield of 40 bushels per acre of barley between the paddocks concerned in the third year. Equally striking contrasts were measured in pastures on the contoured and normally farmed paddocks, the former being more vigorous and definitely a darker green immediately above the contour banks which was probably due to reduced

leaching of nitrates. The dry-matter yield of 12,000 lb. per acre on the contoured pasture compared favourably with 9,000 lb. per acre on the normal pasture. The increased yield of pastures and crops has made it possible to increase the flock progressively.

TARA HILLS EXPERIMENTAL AND DEMONSTRATION FARM, OMARAMA, NORTH OTAGO

This typical hill-country run of 8,000 acres was acquired for conservation purposes because it was typically affected by the complex troubles common to much high country – rabbit infestation, severe depletion of the lower winter country, sheet and wind erosion of the steeper-sunny slopes, over-burning, and declining carrying capacity.

A recuperative programme of fire and rabbit control, irrigation of the flats to relieve the grazing burden on the winter country, oversowing, light topdressing and spelling, reduction in ewe flock and change from half-breds to merinos, fencing, and the use of cattle was undertaken. The result to date is that the wool weight per sheep has been increased 25 per cent, lambing percentages have improved, mortality has been reduced, and the flock is being increased. Cattle have thrived and there has been no resort to burning.



The difficulty in controlling rabbits has impeded the recovery of surface-sown, sunny slopes on the winter country, but there is ample evidence in cages and on some areas to confirm the belief that red clover, yarrow, cocksfoot, tall oatgrass, white clover, and Chewings fescue can be used effectively under moderate stocking to revegetate this country. On the research area valuable pioneer work has been undertaken to study the effect of management on regenerating cover on eroded tussock lands, while extensive strain-testing trials have been undertaken.

To date the most promising strains after withstanding severe grazing are being harvested for seed increase on large plots. *Agropyron intermedium, Bromus inermis, Eragrostis, Agropyron scabrum* (local strain) and cocksfoot are the most promising grasses, while a creeping strain of lucerne, alsyke, red, and white clover have also shown promise on some sites.

EARNSCLEUGH EXPERIMENTAL AREA, CENTRAL OTAGO

This area of 350 acres was made available at a nominal rental to the Council by the Chairman of the Earnscleugh Rabbit Board for experimental purposes, and the Board undertook to control rabbits.

The land was bare, except for scab-weed and briar and small remnants of tussock in favourable sites, and was subject to active wind and sheet erosion. Sheep were withdrawn. Different portions of the block were aerially surface sown in spring and autumn, drilling, sunprong harrowing, and surface-sowing trials were undertaken. Strain trials of likely colonizing plants were laid down, and on suitable sites combined contour banking, pasture furrowing, sunprong harrowing, and seeding and spelling trials were established.

The oversowing trials gave a sparse strike which has improved by spelling and reseeding. Establishment of grasses and clover was best where there was some cover of plants or remnants. Cultivation and drilling trials clearly established the value of cultivation in aiding establishment of seeds either by drilling with Blackmore points or sunprong harrowing. Contouring with furrows or banks emphasized the value of water conservation in establishing seeds sown. The best cover of vigorous clovers and grasses was obtained by the combination of spelling, cultivation with sunprong harrows, and contouring to conserve water.

Fig. 28. Strain trials of various grasses and clovers at Tara Hills Experimental and Demonstration Run, Omarama.

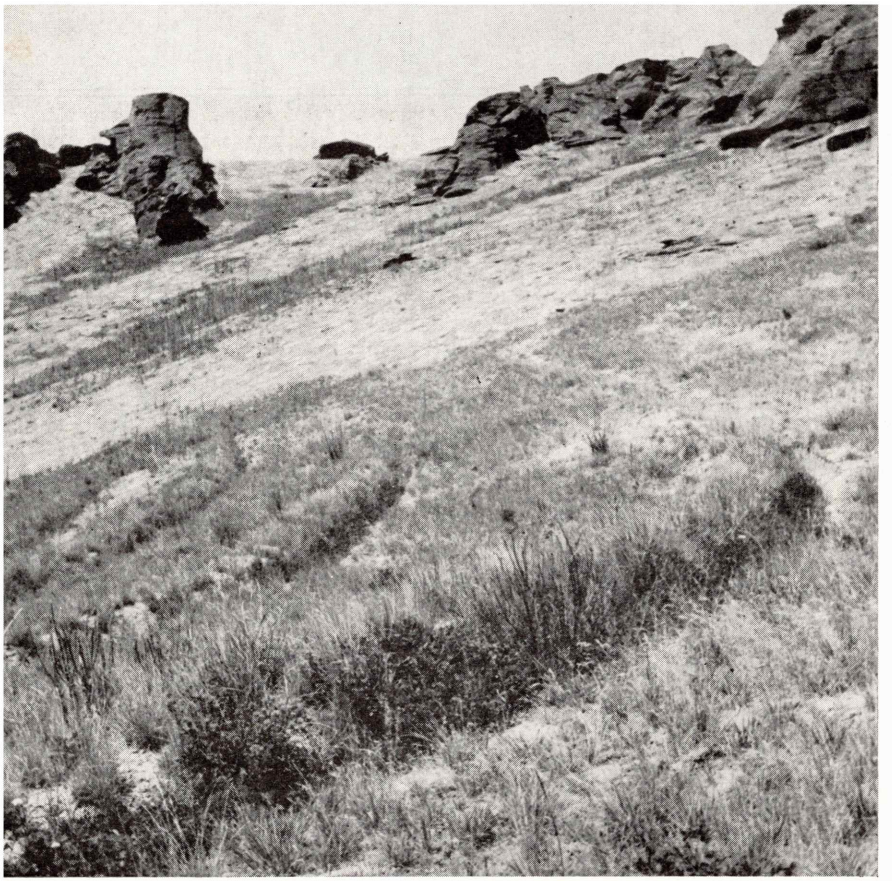


Fig. 29. Establishment of grasses and clovers after cultivation, contouring, and spelling – Earnscleugh Experimental Area, Alexandra.

The over-all effect on this block is that already it is an oasis in the surrounding bare, depleted landscape and there is sufficient establishment of the following clovers and grasses to ensure reseeding to give a satisfactory cover on the area: cocksfoot, yarrow, red clover, white clover, *Bromus inermis,* brown top, Chewings fescue, and hairgrass.

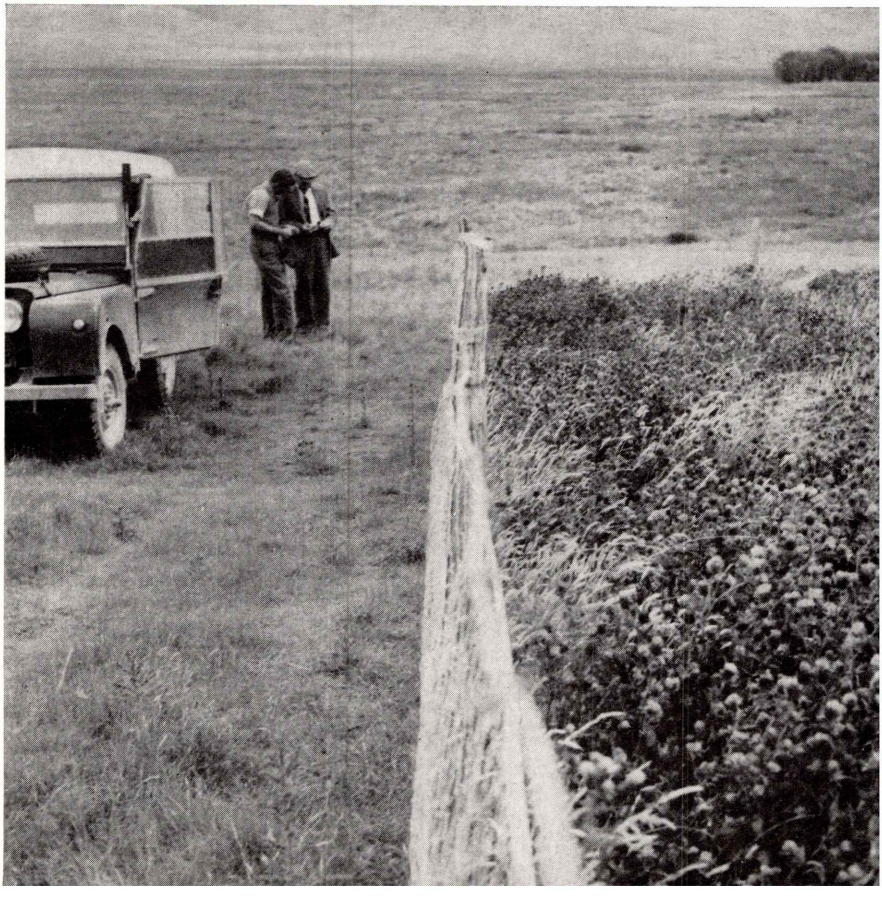
MID-DOME EXPERIMENTAL AREA

This area of badly depleted and actively sheet- and gully-eroding, high country was voluntarily transferred to the Council for experimental purposes.

Spelling, and rabbit and fire control were undertaken with partial success, while trial sowings of grasses and clovers, planting of hardy

trees on steep slopes and in active gullies, and the establishment of a nursery were undertaken. Willows and poplars planted along the deep gully sides and as X-frames across the gullies at intervals have become established effectively and have succeeded in developing a mattress of roots over the gully floor, as well as accumulating debris, to effectively stabilize the gullies. A variety of clovers and grasses were established successfully in rabbit-proof enclosures on bare eroding slopes showing that the prospects were good. Oversowing and topdressing the lower partially covered tussock slopes resulted in excellent establishment of red clover in rabbit-proof enclosures and indicates that the lower country can be improved sufficiently to relieve the grazing on the higher eroded land. As there is a large area of country of this nature in Southland, the depletion and erosion of which is causing serious aggradation and flooding of the streams and rivers, the results of the work on this experimental area are very significant.

Fig. 30. Response to $1\frac{1}{4}$ cwt. of phosphate per acre rabbit control and spelling – Mid-Dome Experimental Area, Southland.



SUMMARY

This first phase of tackling local soil-conservation problems by applying adapted conservation and modified farming practices on a farm scale has had the merit of providing an interim constructive approach to the problems which has won the support of farmers.

Experience has already shown that considerable improvement in the protective nature of the vegetation and its production can be readily achieved in practically all situations. In general it has been found that similar principles apply throughout the range of conditions on experimental farms and that there is much to learn in adapting soil-conservation and farming practices more precisely to the needs of each district. This practical preliminary phase of the work has helped considerably in making evident the more productive aspects of the intensive investigations required in the second phase of this work.

Indications on the three high-country areas are that the practical approach to the solution of the high-country problem of depletion and erosion is to control fire and pests, spell, oversow with grasses and clovers, irrigate where possible, and topdress, fence, and moderately graze blocks in succession starting on the better country first. The improved carrying capacity of the treated land progressively reduces the need to use the higher, steeper, and deteriorating snow-tussock grassland, making it possible to progressively reduce the grazing pressure to assist regeneration.

These experiences of combating erosion by more adequately protecting the soil, rebuilding fertility, and raising land to new and higher levels of production emphasize the great importance of combining good farm management with all the necessary supporting soil-conservation practices, *both* of which must be adapted to the needs of the particular farm. No one measure, useful as it may be, is adequate to meet the over-all requirements of conservation, and all must be fitted into the economic unity of the farm according to a suitably designed farm plan.

The exploratory trials on the experimental and demonstration farms of combined soil-conservation and farming measures are an essential first phase in providing information and demonstrating on a practical basis what conservation farming can achieve in solving the problems, and forms a sound basis for extending conservation practices on to farms generally. They have also emphasized the need for more detailed investigation of several aspects of the hill and high-country problems.

CHAPTER IX

Planning Catchment Control

THE COUNCIL'S AND Catchment Board's method of approach in promoting soil conservation, preventing flooding, and mitigating soil erosion depends largely, as we have seen, on the control of water, the lack of control of which is the principal cause of each. In turn this depends on the soil's capacity to grow protective and stabilizing vegetation which retards the flow and erosive action of water. To be effective this must be achieved over the entire area of each of the natural units of the landscape, the catchment of each river system.

This concept brings into focus the significance of all of the natural units of the catchment, each of which must play its part to this end – the mountain lands, the herb and shrub lands, the protective forests, the productive forests, the high tussock, the lower native and sown grasses, the farm woodlots, planted forests, and the crop lands.

Just as the individual conservation farming practices and their combined effects in supporting each other provide a conservation farming system for problem hill country, the collective effect of conservation farming, together with wise use of unfarmed lands over entire catchments forms the foundation of a system of catchment control.

As erosion in one part of a catchment increases the debris and flood-water discharge, which in turn adversely affects lower land in the catchment, conservation land use in the upper catchment must also be based on the requirements of flood, drainage, and river control in the lower portions. Thus catchment control must be based on plans which make possible the integration of conservation schemes with drainage, flood, and river-control schemes to serve most effectively the needs of the entire catchment.

In order to plan and organize conservation land use on a sound basis and integrate it effectively with river-control requirements, surveys are necessary to determine land capability and conservation requirements. Farm plans may then be prepared which form the practical basis of this work.

SOIL CONSERVATION SURVEYS

These surveys have made it possible to determine the best permanent use of each unit of land in relation to itself and the whole catchment according to the limitations imposed on the land by the physical

factors of slope, soil, erosion, and climate. They provide a scientific evaluation of the physical and farming factors which condition the use of the land resources and the conservation treatment required in the interests of permanent production and the minimizing of soil erosion and flooding. As a result of trial surveys, it has been found desirable to adopt the system devised in the United States of America because it can be adapted to our requirements and has the further advantage of being widely publicized in current literature.

KINDS OF SURVEYS

Two kinds of surveys are recognized, based on the intensity of observation and detail of delineation: (*a*) reconnaissance surveys (published on maps where 1 mile = 1 in.) in which features are examined at wide intervals and the information used for over-all planning on a large scale (these have been adopted as a first step in catchment surveys by the Soil Conservation Council); and (*b*) detailed surveys (published on a scale of 20 chain to 1 in.). More detailed observations are made at closer intervals to provide information for conservation farm planning, using fully the information made available from reconnaissance survey. Aerial photo mosaics are ideal base maps, but, if not available, topographic maps or soil maps are used as base maps.

LAND INVENTORY

This inventory of facts about the land is compiled from its slope, soil erosion, and soil characters (type, depth, texture, permeability, inherent fertility, organic matter) along with details of climate, vegetation, and existing land use.

LAND CAPABILITY

When interpreted, these recorded facts about unit areas of land can be grouped and permit of classification into land capability classes which indicate the ability of the land to produce permanently under specified uses and treatments for each class.

The degree of permanent limitation in land use imposed by natural land characters such as slope, soil, erosion, and wetness is the basis of classification since they affect (*a*) corrective practices required, (*b*) productivity, and (*c*) intensity and manner of use (kind of crops and amount of grazing).

Evaluation of the information obtained about the units of land makes it possible to group them according to these limitations, and to divide the conservation treatment needed into two major land-use-suitability groups—land suited for cultivation and land not suited for cultivation—which are subdivided into classes.

LAND SUITED FOR CULTIVATION

Class I Few limitations and wide latitude of use. Very good land from every standpoint, e.g., the most fertile well drained alluvial lands not subject to floods.

Class II Moderate limitations or risks of damage. Good land from all-round standpoint, e.g., fertile gently sloping land used for crops and pasture.

Class III Severe limitations or risks of damage. Regular cultivation possible if limitations are observed, e.g., sloping land subject to erosion, excess water, or low moisture capacity.

Class IV Very severe limitations. Suited for occasional cultivation or for some kind of limited cultivation, e.g., steep diskable or ploughable land that should only be worked for pasture renewal.

LAND NOT SUITED FOR CULTIVATION

Class V Not suited for cultivation because of wetness, stones, or overflows. Few limitations for grazing or forestry use, e.g., flats and terraces, undrainable or covered with large boulders.

Class VI Too steep, too arid, or too wet for cultivation. Moderate limitations for grazing or forestry, e.g., the stable, unploughable hill country.

Class VII Very steep, rough, arid, or wet. Severe limitations for grazing and forestry, e.g., the unstable steep hill country.

Class VIII Extremely rough, arid, or swampy. Not suited to forestry or grazing, but suited for wild life, watershed protection, and recreation, e.g., steep, very broken unstable country and mountain lands.

CONSERVATION FARM PLANS

As reconnaissance conservation surveys of catchments (1 mile to 1 in.) does not provide sufficient detail for farm planning a more detailed survey of individual farms is made as required (20 chain to 1 in.). Using an aerial photo map as a base map the land capability classes are recorded in more practical detail and the permanent future use of each unit of land is planned within the economy of the farm, and appropriate conservation treatments are developed for each class of land in each new paddock. These plans are then

discussed in detail for practicability of application with the farmer concerned, and the implementing of the plan is staged over a period of years to suit the farmer's resources. This plan combines the desired combination of good farming and special conservation practices dealt with in the previous sections, adapted to the needs of the farm in each case.

Collectively these conservation farm plans will provide the blue print of catchment control, which can be integrated with drainage and river-control operations in the lower catchment.

CATCHMENT CONTROL

The outstanding practical success of catchment-control schemes in other countries more advanced in their soil and water conservation activities, notably United States, reveals their basic importance in developing and utilizing fully the soil and water resources of each natural region. Experience has proved that well planned catchment-control schemes provide the only effective means of integrating satisfactorily and solving the soil-conservation, drainage, and flood-control problems associated with most catchments. The arresting results obtained by constructive forestry practices on the unfarmed lands, conservation farming including drainage and irrigation on all farmed lands, flood-control dams, and controlled river channels amply and permanently justify the planning and work involved in large, medium, and small catchments such as the Tennessee, Muskingum, and Coon Creek projects in the United States. A start has been made in this country by the Council and Catchment Boards.

Soil-conservation surveys have been undertaken on six problematic catchments (total area of 2,900,000 acres) to provide basic data on the land resources, their capability for permanent use, and the conservation measures required to maintain them in production while mitigating soil erosion and excessive run-off.

Conservation farm plans on farming land, supplemented by conservation forestry and other conservation measures needed on the unfarmed portions of catchments, provide a soil-conservation scheme which must be co-ordinated with the river-control and drainage schemes required in the lower parts of the catchment to achieve catchment control.

The Council has arranged to demonstrate the over-all benefits of a co-ordinated catchment-control scheme in the Waimate Creek catchment where the farmers are prepared to apply conservation farming methods to their land to support the stream control work required.

THE NEW CONSERVATION FARMING SYSTEM

New Zealand commences her second century with the new pioneering responsibility of conserving her land and food-producing resources despite the challenge to their permanence by ruinous soil erosion and flooding.

Already several constructive conservation techniques new to the agriculture of this country have been developed through the experimental stage and accepted in practice. Used in combination with, and supported by, prudent farm management, they provide a system of conservation farming for hill country, assure permanent profitable production, and minimize soil erosion and flooding.

1. With aerial farming, a new soil-conservation technique adapted to meet the unique conditions of the hill lands has been created.
2. With modified conservation-grazing, recovery, protection, and production have been secured and demonstrated.
3. With contouring, a new and valuable contribution has been made to farming by controlling the flow water and the loss of soil that assures increased protection of land and production.
4. With conservation use of trees on unstable land a further contribution to agriculture has been made.
5. With fire and pest control, better protection of land is assured.
6. With experience in gully control, methods have been developed to stabilize small catchments and reduce the debris reaching rivers.
7. With conservation surveys and farm plans, blue prints of conservation farming and catchment control are in the making.
8. With integrated catchment-control schemes embracing soil-conservation and river-control requirements, soil erosion and flooding can be minimized.

Although these newly fashioned conservation tools are rough hewn as yet, we can look forward to refining them with research and tempering them with experience to indeed give wings to soil conservation.

MOVIE FILMS
ON
SOIL CONSERVATION

The following films have been produced by the Soil Conservation and Rivers Control Council in black and white or colour with sound tracks as part of its Information Service and have been screened by the Mobile Cinema Unit in catchment districts.

Save Our Soil, black and white (15 min.)
Story of Molesworth, colour (15 min.)
Fire Danger, black and white (10 min.)
Hawke's Bay Floods 1938, black and white (10 min.)
Assets to Ashes, colour (15 min.)
Bringing Back the Balance, colour (15 min.)
Poverty Bay Today and Tomorrow, colour (15 min.)
We Live by Water, black and white (10 min.)
Ruin by Rabbits, colour (16 min.)
Wet Lands Made Fertile, colour (16 min.)
Wither Hills Conservation Work, colour (15 min.)
Green Horizons, black and white (10 min.)
Aerial Topdressing in New Zealand, colour (15 min.)
Trees for Conservation, black and white (10 min.)
Grass for Conservation, black and white (10 min.)
Waimakariri, black and white (15 min.)
Soil Erosion, colour cartoon (8 min.)
Broad Base Terracing, colour (8 min.)
Aerial Fencing, black and white (9 min.)
Catchment Boards at Work series:
Wairarapa, Southland } black and white (20 min.)
South Canterbury, black and white (10 min.)
Poverty Bay Problems, black and white (18 min.)
Hawke's Bay, black and white (10 min.)
Nelson, black and white (10 min.)

Copies have been supplied to the National Film Library, The Terrace, Wellington, for circulation to schools and educational meetings as required.

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Copies of this Bulletin may be obtained free of charge from the Soil Conservation and Rivers Control Council, Government Buildings, Wellington, N.Z., or from the Secretary of the following Catchment Boards:

Hauraki	Box 7	Te Aroha
Poverty Bay	Box 338	Gisborne
Hawke's Bay	Box 233	Napier
Rangitikei	Box 92	Marton
Manawatu	Box 422	Palmerston N.
Wairarapa	Box 41	Masterton
Nelson	Box 41	Nelson
Westland	Box 66	Greymouth
North Canterbury	Box 788	Christchurch
South Canterbury	Box 160	Timaru
Otago	Box 858	Dunedin
Southland	Box 408	Invercargill

and the Waitaki Soil Conservation District Committee, Kurow.

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